NORTH FALLS

Offshore Wind Farm

HABITATS REGULATIONS ASSESSMENT

Draft Report to Inform Appropriate Assessment

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Glossary of Acronyms

ADD	Acoustic Deterrent Device
AEoI	Adverse Effect on Integrity
AfL	Agreement for Lease
AIS	Automatic Identification System
AOE	Alde-Ore Estuary
AON	Apparently Occupied Nests
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
AU	Assessment Unit
B&NNC	Berwickshire and North Northumberland Coast
BAP	Biodiversity Action Plan
BCT	Bat Conservation Trust
BDMPS	Biologically Defined Minimum Population Scales
BDS	Baie de Somme
BDV	Baie des Veys
BEIS	Business Energy and Industrial Strategy
BPM	Best Practical Means
BSM	Baie du Mont Saint-Michel
BTO	British Trust for Ornithology
CEA	Cumulative Effects Assessment
CI	Confidence Interval
CPGR	Counterfactual Population Growth Rate
CPOD	Cetacean Porpoise Detector
CPS	Counterfactual of Population Size
CRM	Collision Risk Modelling
cSAC	Candidate Special Area of Conservation
CTV	Crew Transfer Vessel
CV	Coefficient of Variation
dB	Decibels
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DEP	Dudgeon Extension Project
DESNZ	Department for Energy Security and Net Zero
DO	Dissolved oxygen
EACN	East Anglia Connection Node
EC	European Commission
ECoW	Ecological Clerk of Works
EDR	Effective Deterrent Range
EIA	Environmental Impact Assessment

EMF	Electromagnetic Fields
EMODnet	European Marine Observation and Data Network
EMP	Ecological Management Plan
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ESE	East south east
ETG	Expert Topic Group
EU	European Union
EUNIS	The European Nature Information System
FAME	Future of the Atlantic Marine Environments
FCS	Favourable Conservation Status
FFC	Flamborough and Filey Coast
FLL	Functionally Linked Land
GBS	Gravity Base Structures
GGOW	Greater Gabbard Offshore Wind Farm
GPS	Global Positioning System
GWF	Galloper Wind Farm
ha	Hectare
HAT	High Astronomical Tide
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HGV	Heavy Goods Vehicle
HPAI	Highly Pathogenic Avian Influenza
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
IAMMWG	The Inter-Agency Marine Mammal Working Group
IAQM	The Institute of Air Quality Management
IFCA	Inshore Fisheries and Conservation Authority
ILP	Institute of Lighting Professionals
IMO	International Maritime Organisation
INLA	Integrated Nested Laplace Approximation
INNS	Invasive Non-Native Species
INSPIRE	Impulsive Noise Propagation and Impact Estimator
IROPI	Imperative Reasons of Overriding Public Interest
IRZ	Impact Risk Zone
JNCC	Joint Nature Conservation Committee
kJ	Kilo Joules
km	Kilometre
LA	London Array
LCI	Lower confidence interval

LSE	Likely Significant Effect
m	Metre
MARPOL	International Convention for the Prevention of Pollution from Ships
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMFR	Mean Maximum Foraging Range
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MU	Management Unit
NAF	Nocturnal Activity Factors
NBN	National Biodiversity Network
NCA	National Character Area
NE	North East
NFOW	North Falls Offshore Wind Farm Limited
nm	Nautical Mile
NPS	National Policy Statement
NS	North Sea
NSIP	Nationally Significant Infrastructure Project
NVC	National Vegetation Classification
O&G	Oil and gas
O&M	Operation and Maintenance
OLEMS	Outline Landscape and Ecological Management Strategy
OSP	Offshore Substation Platform
OSPAR	Oslo and Paris Convention - Convention for the Protection of the Marine Environment of the North-East Atlantic
OTNR	Offshore Transmission Network Review
OWF	Offshore Wind Farm
PAH	Polyaromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCoD	Population Consequences of Disturbance
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PLONOR	Pose Little or No Risk to the Environment
PRoWs	Public Right of Ways
pSAC	Potential Special Area of Conservation
pSPA	Potential Special Protection Area
PTS	Permanent Threshold Shift
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
RoC	Review of Consents
RSPB	Royal Society for the Protection of Birds

RTD	Red-Throated Diver
SAC	Special Area of Conservation
SACO	Supplementary Advice on Conservation Objective
SBP	Sub-Bottom Profiler
SCADA	Supervisory Control and Data Acquisition
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCI	Sites of Community Importance
SCOS	Special Committee on Seals
SD	Standard Deviation
SE	South East
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SEP	Sheringham Shoal Extension Project
SIP	Site Integrity Plan
SMASS	Scottish Marine Animal Stranding Scheme
SMP	Seabird Monitoring Programme
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SNH	Scottish Natural Heritage
SNS	Southern North Sea
SoS	Secretary of State
SOV	Service Operation Vessels
SPA	Special Protection Area
SPL_{peak}	Sound Pressure Level
SPR	Scottish Power Renewables
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
TTS	Temporary Threshold Shift
UCI	Upper confidence interval
UK	United Kingdom
UKHPI	UK Habitat of Principal Importance
USBL	Ultra-Short Base Line
UXO	Unexploded Ordnance
WeBS	Wetland Bird Survey
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Glossary of Terminology

Array cables	Cables which link the wind turbine generators with each other and the offshore substation platform(s).
Cable circuit	A bundle which could comprise three power cables; three telecommunications cables; and one earth cable
Cable construction compound	Area set aside to facilitate construction of the onshore cable route. Will be located adjacent to the onshore cable route, with access to the highway.
Haul road	The track along the onshore cable route used by construction traffic to access different sections of the onshore cable route.
Horizontal directional drill	Trenchless technique to bring the offshore cables ashore at the landfall. The technique will also be used for installation of the onshore export cables at sensitive areas of the onshore cable route.
Interconnector cable	Cable between the northern and southern array areas
Interconnector cable corridor	The corridor of the seabed between the northern and southern array areas within which the Interconnector cable will be located.
Jointing bay	Underground structures constructed at regular intervals along the onshore cable route to join sections of cable and facilitate installation of the cables into the buried ducts.
Landfall	The location where the offshore cables come ashore.
Landfall construction compound	Compound at landfall within which HDD or other trenchless technique would take place.
Landfall search area	Locations being considered for the landfall, comprising the Essex coast between Clacton-on-Sea and Frinton-on-Sea.
Link boxes	Underground chambers or above ground cabinets next to the onshore export cables housing low voltage electrical earthing links.
National Grid connection point	The grid connection location for the project. National Grid are proposing to construct new electrical infrastructure to allow the project to connect to the grid, and this new infrastructure will be located at the National Grid connection point.
National Grid substation connection works	Infrastructure required to connect the project to the National Grid’s connection point.
Offshore cable corridor	The corridor of seabed from array areas to the landfall within which the offshore export cables will be located.
Offshore export cables	The cables which bring electricity from the offshore substation platform(s) to the landfall.
Offshore project area	The overall area comprising the array areas and the offshore cable corridor.
Offshore substation platform(s)	Fixed structure(s) located within the array areas, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable voltage for export to shore via offshore export cables.
Onshore cable corridor(s)	Onshore corridor(s) within which the onshore export cables and associated infrastructure will be located. A final onshore cable route for which consent will be sought will be selected from within these corridor(s).
Onshore cable route	Onshore route within which the onshore export cables and associated infrastructure would be located.
Onshore export cables	The cables which take the electricity from landfall to the onshore substation. These comprise High Voltage Alternative Current (HVAC) cables, buried underground.
Onshore project area	The boundary in which all onshore infrastructure required for the project will be located (i.e. landfall; onshore cable route, accesses, construction compounds; onshore substation and National Grid substation extension), as considered within the PEIR.

Onshore scoping area	The boundary in which all onshore infrastructure required for the project will be located, as considered within the North Falls EIA Scoping Report.
Onshore substation	A compound containing electrical equipment required to transform and stabilise electricity generated by the project so that it can be connected to the National Grid.
Onshore substation construction compound	Area set aside to facilitate construction of the onshore substation. Will be located adjacent to the onshore substation (location not yet defined).
Onshore substation zone	Area within which the onshore substation will be located.
Safety zone	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area
Scour protection	Protective materials to avoid sediment being eroded away from the base of the wind turbine generator foundations and offshore substation platform foundations as a result of the flow of water.
The Applicant	North Falls Offshore Wind Farm Limited (NFOW).
The project Or 'North Falls'	North Falls Offshore Wind Farm, including all onshore and offshore infrastructure.
Transition joint bay	Underground structures that house the joints between the offshore export cables and the onshore export cables
Trenchless crossing compound	Areas within the cable corridor(s) which will house trenchless crossing (e.g. HDD) entry or exit points.
Wind turbine generator (WTG)	Power generating device that is driven by the kinetic energy of the wind

1 Introduction

1.1 Purpose of this document

1. The purpose of the Report to Inform Appropriate Assessment (RIAA) is to provide the information necessary for the competent authority to carry out the Appropriate Assessment of the North Falls Offshore Wind Farm (OWF) (hereafter 'North Falls' or 'the Project').

2. This draft version of the RIAA is submitted alongside the Preliminary Environmental Information Report (PEIR) for consultation purposes. The RIAA will be updated following consultation and submitted with the Development Consent Order (DCO) application for the Project.

1.2 Project background

3. North Falls is an extension to the existing Greater Gabbard Offshore Wind Farm (GGOW), and would be located approximately 22km (at its nearest point) off the East Anglian coastline. GGOW was commissioned in 2012 and in February 2017, The Crown Estate launched an opportunity for existing wind farms to apply for project extensions. North Falls Offshore Wind Farm Limited (NFOW) applied for a lease to develop an extension located immediately adjacent to the western boundary of the existing GGOW array areas. In August 2019, The Crown Estate consulted on and then concluded a plan-level Habitats Regulations Assessment (HRA) for the proposed extension projects and confirmed that North Falls (formerly 'Greater Gabbard Extension') would be among seven projects that would be awarded an Agreement for Lease (AfL).

1.2.1 Offshore project area

4. In the context of this report, "offshore" refers to the area below mean high water springs (MHWS).

5. The offshore project area lies in the region of the Outer Thames Estuary, in the southern North Sea. Like GGOW, the North Falls array area is split into two boundaries to facilitate a shipping route. Within these boundaries, wind turbine generators (WTGs), array cables and offshore substation platforms (OSPs) will be installed.

6. The northern and southern array boundaries cover areas of approximately 20.9km^2 (6.1nm^2) and 128.6km^2 (37.5nm^2), respectively. At closest point, the northern array boundary lies approximately 22.5km (12.1nm) from shore, and the southern boundary approximately 37.6km (20.3nm) from shore. An interconnector cable corridor connects the northern and southern array areas.

7. The electricity will be connected to the shore by offshore export cables which will be located within an offshore cable corridor running from the southern array area to the landfall search area between Clacton-on-Sea and Frinton-on-Sea. The offshore cable corridor runs along the northern boundary of the Margate and Long Sands Special Area of Conservation (SAC) and has a small area of overlap with the Outer Thames Estuary Special Protection Area (SPA). The

offshore cable corridor was selected in consultation with Natural England and other stakeholders and was designed to minimise effect on designated sites.

8. The North Falls array areas and offshore cable corridor are collectively referred to as the ‘offshore project area’ (Figure 1.1).

9. The seabed in the array areas is between 5m and 59m below sea level and the substrate is predominantly sand and gravel.

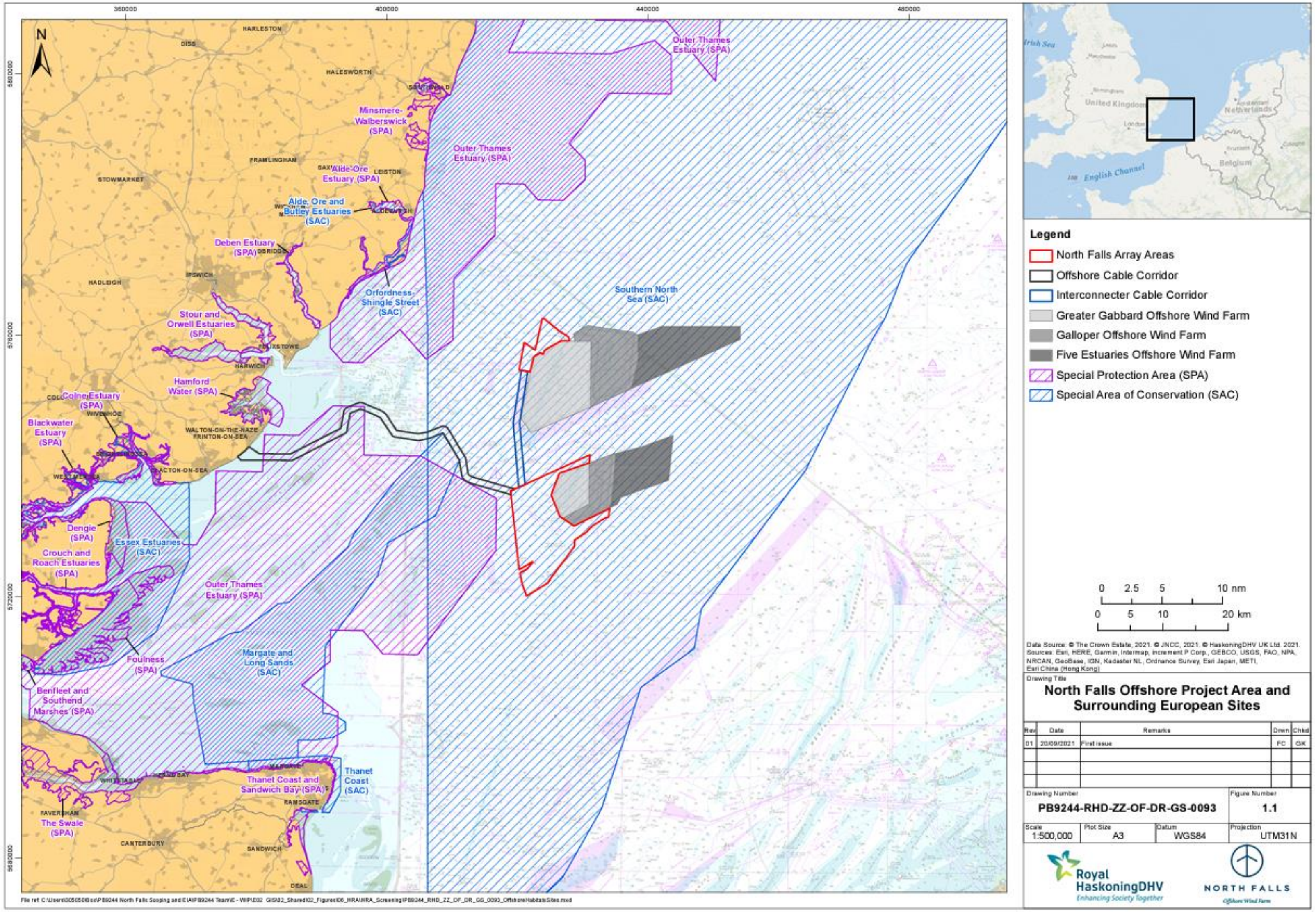

Figure 1.1 North Falls offshore project area and surrounding European sites

1.2.2 Landfall search area

10. As discussed above, the offshore export cables will be brought ashore in the landfall search area between Clacton-on-Sea and Frinton-on-Sea. The precise landfall location between these two settlements will be subject to further site selection, considering relevant consultation feedback and initial Environmental Impact Assessment (EIA) and engineering survey data, in advance of the project's DCO submission.

1.2.3 Onshore project area

11. The project's onshore infrastructure is proposed to be located entirely within the Tendring peninsula of Essex. The location of the project's onshore infrastructure is subject to further refinement through site selection, consideration of relevant consultation feedback and initial environmental and engineering survey data. However, at this stage the following have been identified:

    - Onshore cable corridor(s), comprising at least 204m wide (up to 243m wide) broad corridors in which the onshore export cables will be located;
    - Onshore substation zone, comprising an approximately 60ha zone within which the Project's onshore substation will be located.

12. The footprint of the project's onshore infrastructure is referred to herein as the 'onshore project area' and is shown on Figure 1.2.

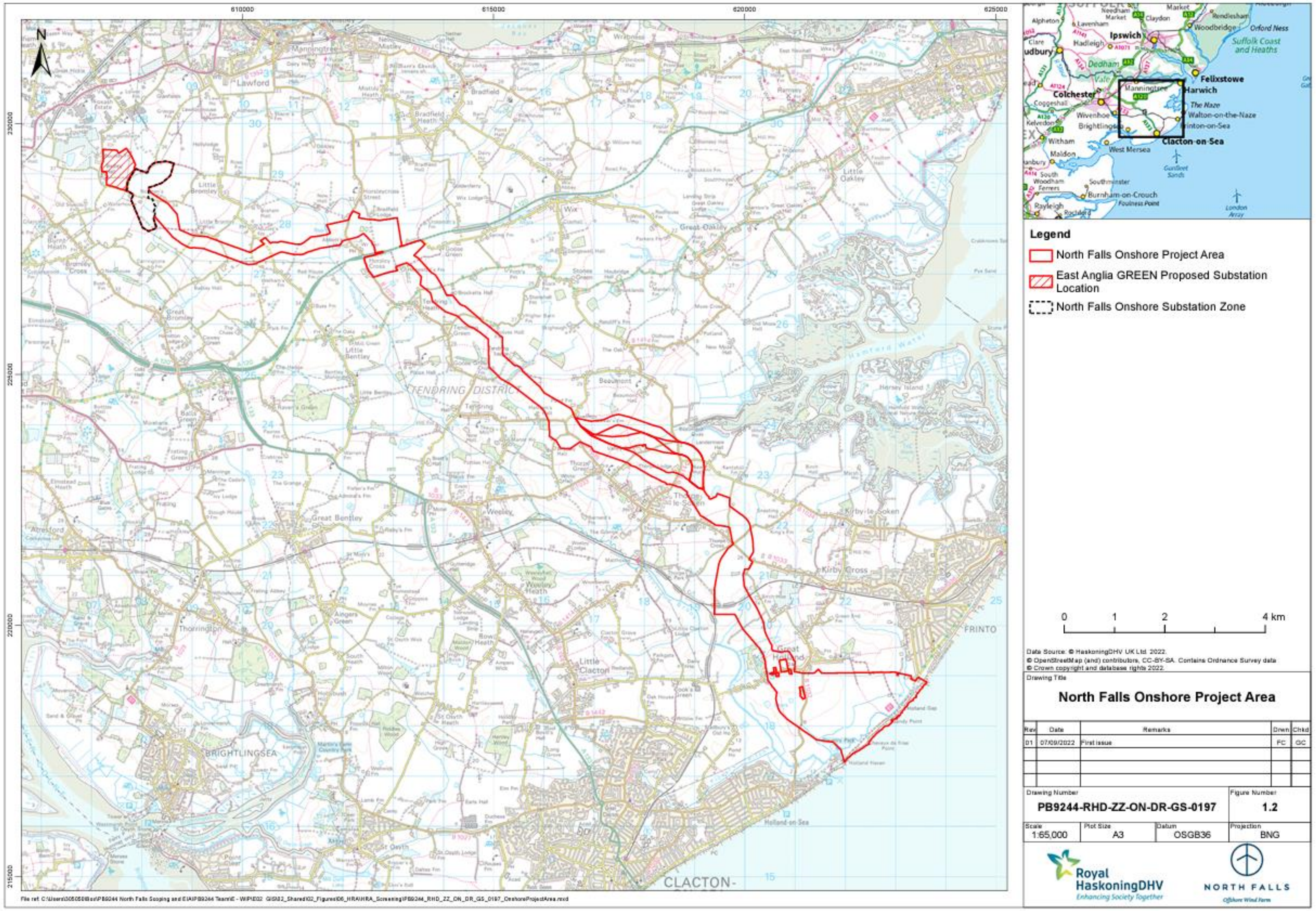

Figure 1.2 North Falls onshore project area

1.3 Legislation, policy and guidance

1.3.1 Overview

13. The HRA process covers features designated under the European Council Directive 2009/147/EC on the conservation of wild birds (the 'Birds Directive') and Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (the 'Habitats Directive').

14. The UK exited the EU on 31st January 2020. However, as described in Section 1.3.3 below, the application of the HRA process currently remains largely unchanged due to the introduction of the European Union (EU) Exit Regulations 2019.

1.3.2 European legislation

1.3.2.1 The Birds Directive

15. The EU Directive on the Conservation of Wild Birds (2009/147/EC) (hereafter called the Birds Directive) provides a framework for the conservation and management of wild birds in Europe. The relevant provisions of the Directive are the identification and classification of SPAs for rare or vulnerable species listed in Annex I of the Directive and for all regularly occurring migratory species (required by Article 4). The Directive requires national Governments to establish SPAs and to have in place mechanisms to protect and manage them. The SPA protection procedures originally set out in Article 4 of the Birds Directive have effectively been replaced by the Article 6 provisions of the Habitats Directive.

1.3.2.2 The Habitats Directive

16. The Habitats Directive provides a framework for the conservation and management of natural habitats, wild fauna (except birds) and flora in Europe. Its aim is to maintain or restore natural habitats and wild species at a favourable conservation status (FCS). The relevant provisions of the Directive are the identification and classification of SAC (Article 4) and procedures for the protection of SACs and SPAs (Article 6). SACs are identified based on the presence of natural habitat types listed in Annex I and populations of the species listed in Annex II. The Directive requires national Governments to establish SACs and to have in place mechanisms to protect and manage them.

1.3.2.3 The Ramsar convention

17. The Convention on Wetlands of International Importance especially as Waterfowl Habitat, as amended in 1982 and 1987 (the 'Ramsar Convention') is an international treaty for the conservation and sustainable use of wetlands of international importance. Ramsar site selection has had an emphasis on wetlands of importance to waterbirds, however non-bird features are increasingly taken into account, both in the selection of new sites and when reviewing existing sites. The UK government has issued a policy statement

which extends to Ramsar sites the same protection at a policy level as SACs and SPAs[1]. Ramsar sites are therefore included in the HRA process.

1.3.3 UK national legislation

1.3.3.1 The Conservation of Habitats and Species Regulations 2017, the Conservation of Offshore Marine Habitats and Species Regulations 2017 and the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019

18. These regulations (hereafter the 'Habitat Regulations') together with the Wildlife and Countryside Act 1981 transpose the Habitats and Birds Directives into UK legislation, together applying to England and Wales, onshore and offshore.

19. The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 make changes to the Habitats Regulations so that they continue to be operable following the UK's exit from the EU on 31st January 2020. While the basic legal framework for HRA is maintained, the EU Exit Regulations transfer functions previously undertaken by the European Commission (EC) to UK Ministers.

20. The Habitats Regulations place an obligation on 'competent authorities' to carry out an Appropriate Assessment of any proposal which is likely to have a significant effect on a European site; to consult Statutory Nature Conservation Bodies (SNCBs) e.g. Natural England; and not to approve an application for a plan or project that would have an adverse effect on the integrity (AEoI) of a European site, except under very tightly constrained conditions known as a "derogation". The competent authority in the case of the DCO application for the Project is the Secretary of State (SoS) for the Department for Energy Security and Net Zero (DESNZ).

1.3.4 Policy

21. National Policy Statements (NPS) are the principal decision-making policy documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to North Falls are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) 2011a);
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011b); and
- NPS for Electricity Networks Infrastructure (EN-5) (DECC 2011c).

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[1] Paragraph 181 of the National Planning Policy Framework states:
"*The following should be given the same protection as habitats [European] sites:*
(a) potential Special Protection Areas and possible Special Areas of Conservation;
(b) listed or proposed Ramsar sites; and
(c) sites identified, or required, as compensatory measures for adverse effects on habitats [European] sites, potential Special Protection Areas, possible Special Areas of Conservation, and listed or proposed Ramsar sites."

22. It is noted that the NPS for Energy (EN-1), the NPS for Renewable Energy Infrastructure (EN-3) and the NPS for Electricity Networks Infrastructure (EN-5) are in the process of being revised. A draft version of each NPS was published for consultation in September 2021 (Department for Business Energy and Industrial Strategy (BEIS), 2021a; BEIS, 2021b; and BEIS, 2021c, respectively). Revised drafts of the NPSs were issued for consultation by DESNZ in March 2023, during the finalisation stage of the North Falls draft RIAA. The 2023 draft NPSs or final versions (if available) will be taken into account in the final RIAA to be submitted with the DCO application.

1.3.5 Guidance

23. The following guidance has been considered during the development of the draft RIAA:

- European Commission (2001): Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites.
- European Commission (2020): EU Guidance on wind energy development in accordance with EU nature directives.
- The Planning Inspectorate Advice Note Nine (2018): Rochdale Envelope.
- The Planning Inspectorate Advice Note Ten (2022): Habitat Regulations Assessment relevant to nationally significant infrastructure projects.
- The Planning Inspectorate Advice Note Seventeen (2019): Cumulative Effects Assessment.
- Department of Energy and Climate Change (2015): Guidelines on the Assessment of Transboundary Impacts of Energy Developments on Natura 2000 Sites outside the UK.
- Ministry of Housing, Communities & Local Government (2019): Guidance on the use of Habitats Regulations Assessment.
- Department for Environment, Food & Rural Affairs, Natural England, Welsh Government, and Natural Resources Wales (2021): Guidance; Habitats regulations assessments: protecting a European site; How a competent authority must decide if a plan or project proposal that affects a European site can go ahead.
- Natural England and Department for Environment Food and Rural Affairs (Defra) (2022) Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards; Phase III: Expectations for data analysis and presentation at examination for offshore wind applications.

2 Overview of HRA process

24. The HRA process consists of several phases that are described further below.

2.1 Stage 1 – Screening

25. For all plans and projects which are not wholly, directly connected with or necessary to the conservation management of a site's qualifying features (such as North Falls), Stage 1 Screening is required, as a minimum.

26. In Stage 1, European sites are screened for Likely Significant Effect (LSE), either alone or in-combination with other plans or projects. Where an LSE on the qualifying features of a site cannot be ruled out, that site is 'screened in' to the Appropriate Assessment. It is important to note that in order to 'screen out' a European Site, the burden of evidence is to show, on the basis of objective information, that there will be no LSE. If the effect may cause LSE, or is not known, this would trigger the need for an Appropriate Assessment.

27. In accordance with the 2018 European Court of Justice ruling in the case of People Over Wind, Peter Sweetman v Coillte Teoranta (C-323/17), mitigation, including embedded mitigation has not been taken into account in Stage 1 Screening.

28. The classes of designations considered within the RIAA are:

- SPAs ;
- Potential SPA (pSPA) – SPAs that are approved by the UK Government but are still in the process of being classified;
- SACs;
- Possible SACs (pSACs) – A site which has been identified and approved to go out to formal consultation;
- Candidate SACs (cSACs) – Following consultation on the pSAC, the site is submitted to the EC for designation and at this stage it is called a cSAC;
- Sites of Community Importance (SCI) – Once UK Ministers approve the site it becomes a SCI, before the national government then designates it as a SAC;
- Sites identified as compensatory measures for adverse effects on any of the above sites; and
- Ramsar sites - protect wetland areas and extend only to "areas of marine water the depth of which at low tide does not exceed six metres".

2.2 Stage 2 – Appropriate assessment

29. As discussed in Section 1.3.3.1, the Appropriate Assessment must be carried out by the competent authority, however information is required from the Applicant for those sites where LSE cannot be ruled out in Stage 1.

30. This report provides an assessment of whether the Project alone or in-combination could adversely affect the integrity of a European site, in view of its conservation objectives. Mitigation measures are taken into account during the assessment.

2.3 Stage 3 – HRA Derogation

31. In cases where the competent authority concludes in the Appropriate Assessment that an AEoI of a European site cannot be ruled out beyond reasonable scientific doubt, consent should not be granted unless the Project satisfies each of the following tests:

    - There are no feasible alternative solutions that would be less damaging or avoid damage to the site;
    - The proposal needs to be carried out for imperative reasons of overriding public interest (IROPI); and
    - Any necessary compensatory measures can be secured.

3 Project description

32. This section provides a summary of the relevant infrastructure parameters of the Project, as well as construction, operation, maintenance and decommissioning strategies. Further detail is provided in Chapter 5 of the PEIR (Volume I) and the relevant worst case scenario for each topic is described in Sections 5.1.2, 6.1.2, 7.1.2, 8.1.2 and 9.1.2.

33. At this stage of the Project's development, some optionality is required in order to future proof the DCO. This is a standard approach and is discussed further in PEIR Chapter 5, Project Description (Volume I).

34. One area of optionality is in relation to the National Grid connection point. NFOW is committed to working with the DESNZ to explore grid connection options as part of the Offshore Transmission Network Review (OTNR) process. NFOW is currently reviewing the following options for the Project's electricity transmission National Grid connection point:

    - Option 1: Onshore electrical connection at a National Grid connection point within the Tendring peninsula of Essex, with a project alone onshore cable route and onshore substation infrastructure;
    - Option 2: Onshore electrical connection at a National Grid connection point within the Tendring peninsula of Essex, sharing an onshore cable route (but with separate onshore export cables) with another project (i.e., Five Estuaries), where practicable; or
    - Option 3: Offshore electrical connection, supplied by a third party electricity network provider. Such a connection will potentially be identified through the OTNR process, in which NFOW is actively engaged.

35. For the purposes of the HRA, option 1 provides the worst case scenario for the HRA screening and Appropriate Assessment and is therefore the basis of the information within this draft RIAA.

3.1 Offshore infrastructure

3.1.1 Wind turbine generators

36. The project has the potential to consist of up to 72 WTGs of its smallest WTG model within the project envelope. The rotor size of these WTG would be up to 250m in diameter.

37. The maximum rotor diameter would be 337m, with a maximum rotor tip height of 397m (above MHWS) for the largest WTG. There would be up to 40 WTGs of this size.

38. The minimum air gap between the sea surface and the rotor tip would be 27m above MHWS for all WTG sizes in the design envelope.

39. The WTGs will incorporate tapered tubular towers and three blades attached to a nacelle housing mechanical and electrical generating equipment.

40. The division of WTGs across the two array boundaries and the overall layout will be informed by site investigation works post consent. It is possible that more than one WTG model will be used across the site.

3.1.2 Foundations

41. The design of foundations for the WTGs and OSPs will be informed by site investigation and procurement, post consent. A number of factors will influence the choice of foundation and the parameters of each foundation option (e.g. the type and size of WTG selected, the nature of the ground conditions, the water depth, metocean characteristics and supply chain constraints). It is possible that more than one type of foundation will be used across the Project area. The following foundation design options are currently being considered:
    - Monopiles;
    - Mono-suction caissons;
    - Jackets on pin piles (3 or 4 legs);
    - Jackets on suction caissons (3 or 4 legs);
    - Jackets on gravity bases (3 or 4 legs); and
    - Gravity Base Structures (GBS).

42. A number of options will be considered to protect the foundations from scour[2] if required, including rock dumping and mattressing.

3.1.3 Offshore electrical infrastructure

43. Offshore electrical infrastructure will include the following components:
    - Array/interconnector cabling;

[2] Scour: sediment eroded away from the base of the foundations as a result of the flow of water.

- OSP; and
- Export cabling to bring the electricity from the array areas to landfall.

3.2 Summary of offshore parameters

Table 3.1 Worst case offshore parameters

FEATURE	WORST CASE PARAMETERS
Number of wind turbine generators (WTGs)	72
Array areas	150km^2
Distance to shore (closest distance)	22.5km
Offshore cable corridor length	57km
No. of offshore export cable circuits	4
Target minimum cable burial depth (where buried)	0.5-3m
Maximum WTG rotor diameter	337m
Maximum rotor tip height	397m above MHWS
Minimum clearance above sea level	27m above MHWS
Minimum separation between WTGs	1,148m downwind; 820m cross wind (smallest WTG) 2,659m downwind; 1,685m cross wind (largest WTG)
Maximum no. of OSP	2
Maximum estimated array/interconnector cable length	228km

3.3 Offshore construction

3.3.1 Seabed preparation

3.3.1.1 Pre-construction surveys

44. A pre-construction survey would be undertaken in advance of cable and foundation installation works. The results of this survey would be used to plan micrositing, where appropriate.

3.3.1.2 Unexploded Ordnance clearance

45. The pre-construction surveys will also be analysed to identify unexploded ordnance which is required to be cleared prior to construction. For the purposes of assessment, an estimated 15 clearance operations are predicted based on engineering experience (12 in the array areas and 3 in the offshore cable corridor). The maximum net explosive quantity of unexploded ordnance (UXO) in this region is predicted to be 698kg.

46. The UXO clearance procedure would be subject to additional marine licensing, to be progressed once the area in which UXO clearance activities are proposed and type of UXO are known.

3.3.1.3 Boulder clearance

47. Pre-construction surveys will identify any requirement for boulder clearance. An estimated 25 boulders in the array areas and 15 boulders in the offshore cable

corridor, of up to 5m in diameter has been included in the assessments. Boulders would be relocated within the offshore project area, outside the foundation locations or route of the cable installation.

3.3.1.4 Pre-lay grapnel run

48. Before cable-laying operations commence, it would be necessary to ensure that the route is free from obstructions such as discarded trawling gear or abandoned cables identified as part of the pre-construction survey. A survey vessel would be used to clear all such identified debris, in a ‘pre-lay grapnel run’.

49. The maximum width of seabed disturbance along the pre-grapnel run would be 12m.

3.3.1.5 Sandwave levelling

50. Mobile sand waves could result in exposure and scouring of the cable or the cable being held in suspension over time. To prevent this, sandwave levelling may be undertaken to enable the cables to be buried into stable sediment beneath the sandwaves. In addition, some foundation options, in-particular GBS would require a level seabed prior to installation.

51. Sandwave levelling in the array areas may be required for the 228km length of array/interconnector cables, with a disturbance width of 24m.

52. Sandwave levelling in the offshore cable corridor may be required for the 250.8km length of offshore export cables, with a disturbance width of 24m. A seabed preparation diameter of 70m may be required for each WTG foundation and 65m diameter for each OSP foundation. A conservative average clearance depth of 5m is assumed.

3.3.2 Pile driving

53. The maximum hammer energy used for pile installation would be 3,000kJ for pin piles and 6,000kJ for monopiles.

54. A soft start (gradual ramping up of hammer energy over consecutive blows) procedure, starting with a hammer energy of approximately 15% of the maximum energy for 10 minutes and then ramping up for a further 20 minutes for the 3000kJ hammer or a further 2 hours for 6000kJ.

55. During the soft start, approximately 10 hammer blows per minute will be used and during ramp up this will increase to 20 blows per minute. Once the ramp up procedure is complete hammer blows would be a maximum of 34 per minute.

56. The maximum predicted time for installation of a monopile is 7.5 hours. For a pin pile the total piling duration would be 3.5 hours per pile and with up to 4 piles per jacket, the total piling duration would be 14 hours (not including breaks in between to move and set up the next pile).

57. There could be two piling operations occurring simultaneously. Within a 24 hour period, two monopiles could be installed or four pin-piles.

3.3.3 Offshore construction programme

58. The final design (e.g. number of WTGs, OSPs, cables, etc.) and supply chain will affect the construction programme, as well as weather conditions during construction.

59. Indicative programmes are provided below in Table 3.2. Offshore working hours during construction are anticipated to be 24/7.

Table 3.2 Indicative offshore construction programme

	YEAR 1				YEAR 2				YEAR 3				YEAR 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Substation installation and commissioning																
Export cable installation																
Foundation installation																
Array/ interconnector cable installation																
WTG installation																
First generation																
WTG and foundation commissioning																

3.4 Operation

60. The operation and control of the wind farm would be managed by a Supervisory Control and Data Acquisition (SCADA) system, connecting each WTG to the onshore control room. The SCADA system would enable the remote control of individual WTGs, the wind farm in general, as well as remote interrogation, information transfer, storage and the shutdown or restart of any wind turbine if required.

3.4.1 Maintenance

61. All offshore infrastructure including WTGs, foundations, cables and offshore substations would be monitored and maintained during the operation and maintenance (O&M) period in order to maximise operational efficiency and safety for other sea users.

62. Typical maintenance activities would include:

- General scheduled service of wind farm components (e.g. WTG and Electrical Equipment);
- Unscheduled repair and maintenance of wind farm components (e.g. WTG and electrical equipment)
- Oil sampling / change;
- Uninterruptible power supply battery change;
- Service and inspections of WTG safety equipment, nacelle crane, service lift, high voltage system, blades;
- Cable burial inspection;
- Cable repair and replacement;
- Foundation inspection and repair; and
- Cable crossing inspection and repair.

3.4.1.1 Cable repairs

63. During the life of the project, there should be no need for scheduled repair or replacement of the subsea cables, however, reactive (unscheduled) repairs and periodic inspection may be required.

64. An estimated four repairs of the offshore export cables and five repairs of the array/interconnector cables, approximately over the project life is included in the EIA. It is assumed 600m would be removed and replaced in the event of a repair operation.

65. In most cases a failure would be repaired by taking out the damaged part of the cable, cutting the cable, inserting a joint, bringing a new segment of cable and jointing the new segment with the old cable.

66. The cable would be unburied using jetting (or removal of mattress/rock protection) and then once the repair is done the opposite (reinstalling the mattress, rock dumping, jetting or other methods of cable burial or protection).

3.4.1.2 Cable reburial

67. Periodic surveys would be required to ensure the cables remain buried and if they do become exposed, re-burial works would be undertaken. An estimated 5km of the array cable and 5km of the offshore export cable requiring reburial over the project life is included in the EIA.

3.4.1.3 WTG maintenance

68. The wind farm would be maintained from shore using a number of O&M vessels (e.g. crew transfer vessels), possibly supported by helicopters.

69. Although it is not anticipated that large components (e.g. WTG blades or substation transformers) would frequently require replacement during the operational phase, the failure of one of these components is possible. Should this be required, a jack-up vessel may need to operate continuously for significant periods to carry out these major maintenance activities.

3.5 Offshore decommissioning

70. Offshore decommissioning is likely to include the removal of all of the WTG and OSP components and cutting of foundations to below seabed level. Cables, cable protection and scour protection may be left in situ.

71. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the Regulator.

3.6 Landfall infrastructure

72. 'Landfall' refers to the area between Mean Low Water Springs (MLWS) and location at which the offshore export cables are brought ashore, and connected to the onshore export cables.

73. Landfall works will comprise the installation of buried High Density Polyethylene (HDPE) ducts beneath the coastline to house the export cables, using Horizontal Directional Drill (HDD) methodology. Temporary works to undertake the landfall HDD will take place within a temporary landfall compound, located landward of the coastline.

74. The offshore export cables are then pulled through the pre-installed ducts to transition joint bays located within the temporary landfall compound, where they are jointed to the onshore export cables. The HDD would exit in the subtidal zone, in 1 to 8m water depth.

3.7 Onshore infrastructure

3.7.1 Onshore cable corridor(s)

75. Buried export cables will be constructed to connect the landfall to the Project's onshore substation, and on to the National Grid connection point. The onshore cables would be laid in up to 16 trenches, within a temporary working width of up to 60m wide (up to 122m where HDD is used). Cables would be installed a minimum of 0.85m (from top of protection tiles to surface) below ground level, and cables would typically be 200mm in diameter (the duct being larger).

76. Cable installation works will comprise duct installation using a combination of 'open cut' trench excavation and trenchless techniques (e.g. HDD) at obstacle crossings. Once ducts are installed, cable pulling will be undertaken using the pre-installed ducts. Cables will be joined within joint bays located along the onshore cable corridor(s). Temporary works required to facilitate construction will include construction accesses, temporary construction compounds (up to 7) and HDD compounds.

3.7.2 Onshore substation

77. A new onshore substation will be constructed within an onshore substation zone located west of the village of Little Bromley, Tendring district. The new substation will comprise the electrical equipment required to connect the Project to the National Grid, including electrical transformers, air / gas insulated switchgear, control and storage buildings, and other ancillary equipment. The onshore substation will also include hard and soft landscaping, drainage and access infrastructure.

78. The exact location of the equipment is still subject to ongoing project design, but it is proposed to be located within the onshore substation zone (see Figure 1.1).

3.7.3 Connection to the National Grid

79. The North Falls onshore substation will connect into the National Grid at the new National Grid East Anglia Connection Node (EACN) 400kV substation, proposed to be constructed on the Tendring Peninsula.

80. National Grid's substation will be consented separately by National Grid as part of their DCO for the East Anglia GREEN Project. The works to construct the new National Grid substation will be undertaken by National Grid.

81. The North Falls DCO application will include works for the cable connection between the new North Falls onshore substation and the new National Grid substation, and some specific works to facilitate the connection within the National Grid substation, namely installation of switchgear, protection and control equipment (if required), and temporary infrastructure to facilitate construction of this electrical equipment.

82. National Grid have identified a search area within which they anticipate their new substation will be located. This is the hatched highlighted area illustrated on Figure 1.2. At this stage National Grid have not confirmed the proposed location of the substation within this search area, nor any information regarding the parameters of the substation. Therefore, the whole search area has been considered within the assessment presented below.

3.8 Summary of onshore parameters

Table 3.3 Worst case landfall parameters

FEATURE	WORST CASE PARAMETERS
Maximum number of export circuits	4
Maximum number of transition joint bays	4

FEATURE	WORST CASE PARAMETERS
Permanent land take for each transition joint bay (per bay)	4 x 15m
Landfall construction compound dimensions	100 x 200m
Proposed landfall installation method	HDD
Maximum number of HDDs	5
Maximum length of HDD	1,100m
Drill exit location	Subtidal exit below MHWS (up to 8m depth).

Table 3.4 Worst case onshore export cable parameters

FEATURE	WORST CASE PARAMETERS
Electrical connection type	High Voltage Alternating Current (HVAC)
Maximum number of onshore circuits	Up to 4 circuits, comprising up to 3 power cables, 3 telecommunications cables and 1 earth cable in each circuit
Number of cable construction compounds	Up to 7
Temporary construction compound footprint	150 x 150m (general cable construction compounds) 100 x 100m (small cable construction compounds)
Indicative external cable diameter	200mm
Proposed onshore cable route construction width	Up to 60m (open cut trenching) Up to 122m (trenchless installation (e.g. HDD))
Approximate onshore cable length	24km
Number of joint bays	80 - 192
Joint bay dimensions	13 x 5m
Estimated number of link boxes	Up to 196
Number of trenches for all cables	Up to 4
Cable trench dimensions	3.50 x 2m (width x depth)
Maximum depth at trenchless crossings	20m
HDD compound dimensions	80 x 120m (major HDD compounds) 40 x 120m (minor HDD compounds)
Haul road carriageway width	6m
Haul road width passing places and drainage	10m
Haul road spacing at passing places	500m
Replanting restrictions	37m swathe in which only shrubs (growth up to max. 5m height) can be planted.

Table 3.5 Worst case onshore substation parameters

FEATURE	WORST CASE PARAMETERS
Maximum onshore substation footprint	267 x 300m
Indicative number of buildings	5
Construction compound indicative dimensions	150 x 250m

3.9 Landfall export cable installation

83. Cable landfall works will comprise installation of HDPE cable ducts through HDD from landward of MHWS, exiting in the sub-tidal zone, therefore avoiding direct impacts to the intertidal zone. Cables will be pulled through ducts and cable transition joint bays will be installed to connect the onshore to the offshore export cables. Installation by HDD would require a fenced landfall construction compound of up to 100 x 200m to undertake the works, with space for up to four transition joint bays.

3.10 Onshore construction

84. Construction activities required to facilitate construction of the Project's onshore infrastructure include, at the landfall and onshore cable corridor(s):

- top-soil stripping;
- construction access, temporary haul road, construction compound and construction drainage construction;
- trenching works;
- duct installation;
- trench back-filling and reinstatement;
- HDD and other trenchless crossing techniques; and
- cable-pulling and cable jointing in situ;
- Installation of cable link boxes.

85. And at the onshore substation:

- top-soil stripping;
- construction and operational access, temporary haul road and construction compound construction;
- earthworks to create a substation platform;
- piling (if required);
- concrete pouring (for the substation platform);
- installation of electrical equipment;
- installation of drainage infrastructure;
- reinstatement and soft landscaping.

86. The works will require a range of equipment, including dozers, generators, excavators, HDD rigs etc., predominantly delivered by Heavy Goods Vehicle (HGV) (with the exception of electrical transformers, which are likely to constitute Abnormal Loads) using the local road network.

3.10.1 Onshore construction programme

87. Onshore construction is expected to commence around 2026 at the earliest, with the aim of being operational by 2030. Onshore construction works are

expected to be undertaken 7am-7pm Monday – Saturday (no working Sundays or bank holidays), however 24 hour working may be required during drilling works at major HDD locations (e.g. landfall, crossings of major transport infrastructure).

88. The following approximate durations for different activities have been defined at this stage:

- Landfall: 13 months (of which HDD will take place over 6 months);
- Onshore cable corridor(s): 18 – 24 months (of which cable installation will take place over 12 months; Major HDD (each location) will take place over 8 months (of which HDD = 4 months); Minor HDD crossings will take place 2 months;
- Onshore substation: 6 months site preparation, 24 months construction.

3.11 Onshore operation and maintenance

89. During the operational period, the onshore substation would not be manned, however access would be required periodically for routine maintenance activities. Normal operating conditions would not require lighting at the onshore substation, although low level movement detecting security lighting may be utilised for health and safety purposes. Temporary lighting during working hours would be provided during maintenance activities only.

90. There is no ongoing requirement for regular maintenance of the onshore cables following installation, however access to the onshore cables would be required to conduct emergency repairs, if necessary.

3.12 Onshore decommissioning

91. No decision has been made regarding the final decommissioning policy for the onshore cables and substation, as it is recognised that industry best practice, rules and legislation change over time. Onshore decommissioning is likely to include the removal of all of the onshore substation equipment, and landscaping and reinstatement of the site. It is likely the cables would be removed from the ducts and recycled, with the transition pits and ducts capped and sealed then left in situ.

92. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator.

4 Screening conclusions

4.1 Benthic ecology (Annex I habitat in SACs and SPA supporting habitat)

93. As discussed in Section 1.2.1, the offshore cable corridor runs along the northern boundary of the Margate and Long Sands SAC and has a small area of overlap with the Outer Thames Estuary SPA. There is therefore potential for indirect effects which could result in LSE on the designated Annex I habitat feature of Margate and Long Sands SAC from North Falls, alone or in combination.

94. As there is no overlap between the offshore project area and the Margate and Long Sands SAC, there is no pathway for direct effects to occur. The following indirect effects during construction, O&M and decommissioning are screened in and assessed in Section 5.2.3:

- Changes to suspended sediment concentrations and bedload transport
- Smothering; and
- Re-mobilisation of contaminated sediments.

95. In addition, an LSE has been identified for the supporting habitats of the Outer Thames Estuary SPA for North Falls, alone or in-combination.

96. All other European sites designated for Annex I habitats are screened out on the basis that they are beyond the zone of influence of the Project and therefore have no potential for LSE, for the Project alone or in-combination with other plans and projects. For further information on the rationale, see Appendix 1.

4.2 Fish (Annex II species)

97. Direct or indirect LSE from North Falls (alone or in-combination) can be ruled out for all sites designated for Annex II migratory fish species, therefore SACs with Annex II fish species as qualifying features are not discussed further in this document. For further information on the rationale, see Appendix 1.

4.3 Marine mammals (Annex II species)

98. For marine mammals, the approach to the RIAA primarily focuses on the potential for connectivity between individual marine mammals from designated populations and the North Falls offshore project area (i.e. demonstration of a clear source-pathway-receptor relationship). This is based on the distance of the offshore project area from a European site, the range of each effect and the potential for animals from a European site to be within range of that effect.

99. The RIAA therefore considers European sites which meet the following criteria:

- The distance between the potential effect of the North Falls offshore project area and a European site with marine mammals as a qualifying feature is within the range for which there could be an interaction. For example, the pathway is not too long for significant noise propagation and therefore the site is within the area of effect for underwater noise effects.
- The distance between the North Falls offshore project area and resources on which the qualifying marine mammal feature depends, such as key habitats or areas of prey species is within the potential area of effect. There is the potential for an indirect effect acting through prey or access to habitat.
- The likelihood that a foraging area or a migratory route occurs within any area of effect of the North Falls offshore project area. This applies to mobile qualifying features when outside of a European site.

100. The approach to screening for seal species was undertaken based on the identified connectivity with SACs through tagging studies, and those SACs that are within the Management Units (MUs) with identified connectivity for seal species.

101. Table 4.1 shows the European sites and qualifying features that have been screened in for LSE.

102. All other European sites designated for Annex I marine mammal species are screened out on the basis of no potential for LSE. For further information on the rationale, see Appendix 1.

103. The potential impacts on marine mammals are:

- Piling, other construction activities, vessels, operational turbines, O&M activities and decommissioning activities);
- Any barrier effects from underwater noise;
- Any increased collision risk with vessels;
- Disturbance at seal haul-out sites;
- Disturbance of foraging at sea;
- Changes to water quality;
- Changes to prey resources; and
- In-combination effects.

Table 4.1 Summary of marine mammal SACs and features screened in

Site	Qualifying feature screened in
Southern North Sea SAC	Harbour porpoise *Phocoena phocoena*
Humber Estuary SAC and Ramsar	Grey seal Halichoerus grypus
The Wash and North Norfolk Coast SAC	Harbour seal Phoca vitulina
Vlaamse Banken SAC	Harbour porpoise Harbour seal Grey seal
SBZ 1 / ZPS 1 SPA	Harbour seal
Vlakte van de Raan SCI	Harbour porpoise Harbour seal Grey seal
Bancs des Flandres SAC	Harbour porpoise Harbour seal Grey seal
Dunes De La Plaine Maritime Flamande SAC	Harbour seal
Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC	Harbour porpoise Harbour seal Grey seal
Recifs Gris-Nez Blanc-Nez SAC	Harbour porpoise Harbour seal Grey seal
Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC	Harbour porpoise Harbour seal Grey seal
Vlakte van de Raan SAC	Harbour porpoise

Site	Qualifying feature screened in
	Harbour seal Grey seal
Voordelta SAC and SPA	Harbour porpoise Harbour seal Grey seal
Westerschelde and Saeftinghe SAC	Harbour porpoise Harbour seal Grey seal

4.4 Offshore ornithology (Birds Directive Annex I and migratory species)

104. Birds present in offshore waters and potentially affected by North Falls are predominantly seabirds (defined for this report as auks, gulls, terns, gannets, skuas, shearwaters, petrels and divers). These species have the potential to be present during the breeding season, non-breeding season and the spring / autumn migration/passage periods. Other bird species that may be affected by North Falls include waterfowl (swans, geese, ducks and waders) and other bird species which may fly through the Project areas during spring and/or autumn migration/passage periods.

105. For offshore ornithology receptors during the breeding season, the HRA screening (Appendix 1) focused primarily on the potential for connectivity between seabirds breeding at colonies which are classified as SPAs, and the Project. This was based on the Mean Maximum Foraging Range (MMFR) as identified by the industry standard report: Woodward et al. (2019).

106. Outside the breeding season, seabirds breeding at SPAs located beyond the breeding season foraging range of the Project may spend part or all of the non-breeding season in the vicinity of the Project, either wintering or migrating through on spring and/or autumn passage to wintering areas. During this time the number of SPAs with potential connectivity to North Falls will increase. For seabirds during the non-breeding season, screening is informed by the Furness (2015) report on non-breeding populations of seabirds in UK Waters.

107. Other bird species that may be affected by North Falls include waterfowl (swans, geese, ducks and waders) and other bird species which may fly through the Project areas during spring and/or autumn migration/passage periods. For non-seabird migratory species, SPAs within 100km of the Project were screened in.

108. Thus the HRA screening exercise considered SPAs which either overlap with the offshore footprint of North Falls (array areas and offshore cable corridor) or are within the relevant species' foraging ranges during the breeding and non-breeding season, and/or may pass through the site during spring and autumn passage. Further background and rationale for the screening methodology is included in the HRA screening report (Appendix 1).

109. The outcome of the screening exercise (and subsequent consultation with Natural England) was that the sites and qualifying features in Table 4.2 were screened in for Appropriate Assessment. Further details of screening decisions for individual sites and qualifying features are included in the HRA screening report (Appendix 1).

110. This draft RIAA provides information to inform Appropriate Assessments for the relevant qualifying features of the three key SPAs, where Natural England has advised that North Falls has potential to contribute to an AEoI in combination with other OWFs in UK waters. These sites are:

- The Outer Thames Estuary SPA (red throated diver, non-breeding)
- The Alde-Ore Estuary SPA and Ramsar site (lesser black-backed gull, breeding)
- Flamborough and Filey Coast SPA (kittiwake, guillemot and razorbill, breeding).

111. The RIAA which accompanies the DCO submission will include a shadow Appropriate Assessment for all SPA / Ramsar sites screened in for LSE in relation to North Falls.

Table 4.2 North Falls: Summary of HRA screening for UK SPA and Ramsar Sites with offshore ornithology features.

Site	Qualifying Feature Screened In
Outer Thames Estuary SPA	Red-throated diver, non-breeding Common tern, breeding
Alde-Ore Estuary SPA and Ramsar site	Sandwich tern, breeding Lesser black-backed gull, breeding Avocet, breeding Avocet, non-breeding Marsh harrier, breeding Redshank, non-breeding Ruff, non-breeding Notable assemblage of breeding and wintering wetland birds
Sandlings SPA	Nightjar, breeding Woodlark, breeding
Minsmere-Walberswick SPA and Ramsar	Avocet, breeding Marsh harrier, breeding Nightjar, breeding Shoveler, breeding Shoveler, wintering Teal, breeding Gadwall, breeding Gadwall, wintering White-fronted goose, wintering Hen harrier, wintering Assemblage of rare breeding birds associated with marshland and reedbeds
Deben Estuary SPA and Ramsar	Avocet, wintering Dark-bellied brent goose, wintering
Hamford Water SPA and Ramsar	Avocet, wintering Black-tailed godwit, wintering Dark-bellied brent goose, wintering Grey plover, wintering Redshank, wintering, passage Ringed plover, wintering, passage Shelduck, wintering

Site	Qualifying Feature Screened In
	Teal, wintering
Stour and Orwell Estuaries SPA and Ramsar	Avocet, breeding Black-tailed godwit, wintering Dark-bellied brent goose, wintering Dunlin, wintering Grey plover, wintering Knot, wintering Pintail, wintering Redshank, wintering, Redshank, autumn passage Waterbird assemblage (great crested grebe, cormorant, shelduck, wigeon, gadwall, goldeneye, ringed plover, lapwing, curlew, turnstone)
Thanet Coast and Sandwich Bay SPA and Ramsar	Golden plover, wintering Turnstone, wintering
Benacre to Easton Bavents SPA	Marsh harrier, breeding
Colne Estuary SPA and Ramsar	Pochard, breeding Ringed plover, breeding Dark-bellied brent goose, wintering Black-tailed godwit, wintering Hen harrier, wintering Redshank, wintering Waterbird assemblage, wintering (cormorant, mute swan, shelduck, goldeneye, ringed plover, grey plover, sanderling, dunlin, curlew)
Broadland SPA and Ramsar	Marsh harrier, breeding Bewick's swan, wintering Hen harrier, wintering Ruff, wintering Gadwall, wintering Shoveler, wintering Whooper swan, wintering Wigeon, wintering
Foulness SPA and Ramsar	Sandwich tern, breeding Common tern, breeding Avocet, breeding Ringed plover, breeding Bar-tailed godwit, wintering Dark-bellied brent goose, wintering Grey plover, wintering Hen harrier, wintering Knot, wintering Oystercatcher, wintering Redshank, wintering, passage Waterbird assemblage (shelduck, dunlin, curlew)
Stodmarsh SPA and Ramsar	Gadwall, breeding Gadwall, wintering Bittern, wintering Hen harrier, wintering Shoveler, wintering

Site	Qualifying Feature Screened In
	Breeding bird assemblage (great crested grebe, lapwing, redshank, snipe, grasshopper warbler, Savi's warbler, sedge warbler, reed warbler) Waterbird assemblage, wintering (white-fronted goose, wigeon, mallard, pochard, tufted duck, water rail, lapwing, snipe)
Dengie SPA and Ramsar	Dark-bellied brent goose, wintering Grey plover, wintering Hen harrier, wintering Knot, wintering Waterbird assemblage, wintering (dunlin, black-tailed godwit, bar-tailed godwit)
Blackwater Estuary SPA and Ramsar	Pochard, breeding Ringed plover, breeding Black-tailed godwit, wintering Dark-bellied brent goose, wintering Dunlin, wintering Grey plover, wintering Hen harrier, wintering Waterbird assemblage, wintering (cormorant, shelduck, gadwall, teal, goldeneye, ringed plover, curlew, redshank)
Abberton Reservoir SPA and Ramsar	Coot, wintering Gadwall, wintering Goldeneye, wintering Great crested grebe, wintering Mute swan, wintering Pochard, wintering Shoveler, wintering Teal, wintering Tufted duck, wintering Wigeon, wintering Waterbird assemblage, late summer passage/moult
Crouch and Roach Estuaries SPA and Ramsar	Dark-bellied brent goose, wintering Waterbird assemblage, wintering
Breydon Water SPA and Ramsar	Common tern, breeding Avocet, wintering Bewick's swan, wintering Golden plover, wintering Lapwing, wintering Ruff, passage Waterbird assemblage
The Swale SPA and Ramsar	Dark-bellied brent goose, wintering Dunlin, wintering Redshank, passage Grey plover, wintering Breeding bird assemblage (shelduck, mallard, moorhen, coot, lapwing, redshank, reed warbler, reed bunting) Waterbird assemblage, wintering (oystercatcher, ringed plover, redshank, shelduck, wigeon, teal, curlew)
Benfleet and Southend Marshes SPA and Ramsar	Dark-bellied brent goose, wintering Dunlin, wintering Grey plover, wintering

Site	Qualifying Feature Screened In
	Knot, wintering Ringed plover, wintering Waterbird assemblage, wintering
Thames Estuary and Marshes SPA and Ramsar	Avocet, wintering Black-tailed godwit, wintering, passage Dunlin, wintering Grey plover, wintering Hen harrier, wintering Knot, wintering Redshank, wintering Ringed plover, passage Waterbird assemblage
Medway Estuary and Marshes SPA and Ramsar	Avocet, breeding Avocet, wintering Dark-bellied brent goose, wintering Dunlin, wintering Grey plover, wintering Knot, wintering Pintail, wintering Redshank, wintering Ringed plover, wintering Shelduck, wintering Breeding bird assemblage (oystercatcher, lapwing, ringed plover, redshank, shelduck, mallard, teal, shoveler, pochard, common tern) Waterbird assemblage, wintering (red-throated diver, great crested grebe, cormorant, mallard, teal, shoveler, pochard, oystercatcher, Bewick's swan, hen harrier, merlin, golden plover, short-eared owl, kingfisher)
Breckland SPA	Nightjar, breeding Stone curlew, breeding Woodlark, breeding
Dungeness, Romney Marsh and Rye Bay SPA and Ramsar	Avocet, breeding Common tern, breeding Sandwich tern, breeding Marsh harrier, breeding Aquatic warbler, passage Bewick's swan, wintering Bittern, wintering Golden plover, wintering Hen harrier, wintering Ruff, wintering Shoveler, wintering Mute swan, wintering Waterbird assemblage, wintering (European white-fronted goose, wigeon, gadwall, pochard, little grebe, great crested grebe, cormorant, coot, sanderling, whimbrel, common sandpiper, lapwing)
North Norfolk Coast SPA and Ramsar	Common tern, breeding Sandwich tern, breeding
The Wash SPA	Common tern, breeding
Chichester and Langstone Harbours SPA	Common tern, breeding

Site	Qualifying Feature Screened In
	Sandwich tern, breeding
Solent and Southampton Water SPA and Ramsar	Common tern, breeding Sandwich tern, breeding
Flamborough and Filey Coast SPA	Gannet, breeding Guillemot, breeding Kittiwake, breeding Razorbill, breeding Seabird assemblage
Teesmouth and Cleveland Coast SPA	Common tern, breeding
Northumbria Coast SPA	Arctic tern, breeding
Coquet Island SPA	Arctic tern, breeding Common tern, breeding Roseate tern, breeding Sandwich tern, breeding
Farne Islands SPA	Arctic tern, breeding Common tern, breeding Guillemot, breeding Sandwich tern, breeding
Forth Islands SPA	Arctic tern, breeding Common tern, breeding Gannet, breeding Lesser black-backed gull, breeding Puffin, breeding Roseate tern, breeding Sandwich tern, breeding
Imperial Dock Lock, Leith SPA	Common tern, breeding
Fowlsheugh SPA	Guillemot, breeding Kittiwake, breeding
Ythan Estuary, Sands of Forvie and Meikle Loch (extension) SPA	Common tern, breeding Sandwich tern, breeding
Loch of Strathbeg SPA	Sandwich tern, breeding
Troup, Pennan and Lion's Heads SPA	Guillemot, breeding
Inner Moray Firth SPA and Ramsar	Common tern, breeding
Cromarty Firth SPA	Common tern, breeding
East Caithness Cliffs SPA	Guillemot, breeding Herring gull, breeding Kittiwake, breeding Razorbill, breeding
Caithness and Sutherland Peatlands SPA and Ramsar	Red-throated diver, breeding
North Caithness Cliffs SPA	Guillemot, breeding

Site	Qualifying Feature Screened In
Pentland Firth Islands SPA	Arctic tern, breeding
Hoy SPA	Great skua, breeding Red-throated diver, breeding
Auskerry SPA	Arctic tern, breeding
Orkney Mainland Moors SPA	Red-throated diver, breeding
Rousay SPA	Arctic tern, breeding
Marwick Head SPA	Guillemot, breeding
Fair Isle SPA	Arctic tern, breeding Guillemot, breeding
West Westray SPA	Arctic tern, breeding Guillemot, breeding
Papa Westray (North Hill and Holm) SPA	Arctic skua, breeding Arctic tern, breeding
Sumburgh Head SPA	Arctic tern, breeding
Mousa SPA	Arctic tern, breeding
Noss SPA	Gannet, breeding Great skua, breeding Guillemot, breeding
Foula SPA	Arctic tern, breeding Great skua, breeding Guillemot, breeding Puffin, breeding Red-throated diver, breeding
Papa Stour SPA	Arctic tern, breeding
Fetlar SPA	Arctic tern, breeding Great skua, breeding
Otterswick and Graveland SPA	Red-throated diver, breeding
Ronas Hill – North Roe and Tingon SPA and Ramsar	Great skua, breeding Red-throated diver, breeding
Hermaness, Saxa Vord and Valla Field SPA	Gannet, breeding Great skua, breeding Red-throated diver, breeding

4.5 Onshore ornithology (SPAs and Ramsar sites)

112. There is potential for indirect effects, in particular on ex situ habitats which support the qualifying features outside the site boundaries, which could result in LSE on the qualifying features of the European sites shown in Table 4.3.

113. All other SPAs and Ramsar sites designated for onshore bird species are screened out on the basis of no potential for LSE. For further information on the rationale, see Appendix 1.

Table 4.3 Summary of onshore SPAs and features screened in

Site	Qualifying feature screened in
Hamford Water SPA	The site qualifies under Article 4.1 and 4.2 of the Birds Directive (2009/147/EC) for supporting the following species: Little tern *Sternula albifrons* 39 pairs – breeding (78 breeding adults) 2010 – 2014, 2.1% of GB population Avocet *Recurvirostra avosetta* 99 individuals – wintering 1986/87 – 1990/91, 7% of GB population Dark bellied brent goose *Branta bernicla bernicla*, 5,650 individuals – wintering, 1986/87 – 1990/91, 2% of biogeographic population Shelduck *Tadorna tadorna* 840 individuals – wintering 1986/87 – 1990/91 1% of GB population1 Teal *Anas crecca* 3,630 individuals – wintering 1986/87 – 1990/91 2% of GB population Ringed plover *Charadrius hiaticula* 620 individuals – wintering 1986/87 – 1990/91 1% of biogeographic population Grey plover *Pluvialis squatarola* 1,080 individuals – wintering 1986/87 – 1990/91 2% of GB population1 Black-tailed godwit *Limosa limosa* 1,580 individuals – wintering 1986/87 – 1990/91 2% of biogeographic population Redshank *Tringa tetanus* 1,240 individuals – wintering 1986/87 – 1990/91 1% of biogeographic population
Hamford Water Ramsar	Ramsar criterion 6 – species/population occurring at levels of international importance. Qualifying Species/populations (as identified at designation): Species with peak counts in spring/autumn: Ringed plover, *Charadrius hiaticula*, Europe/Northwest Africa 1169 individuals, representing an average of 1.6% of the population (5 year peak mean 1998/9-2002/3) Common redshank , *Tringa totanus totanus*, 2099 individuals, representing an average of 1.8% of the GB population (5 year peak mean 1998/9-2002/3) Species with peak counts in winter: Dark-bellied brent goose, *Branta bernicla bernicla*, 3629 individuals, representing an average of 1.6% of the population (5 year peak mean 1998/9-2002/3) Black-tailed godwit , *Limosa limosa islandica*, Iceland/W Europe 377 individuals, representing an average of 1% of the population (5 year peak mean 1998/9- 2002/3) Species/populations identified subsequent to designation for possible future consideration under criterion 6. Species with peak counts in winter: Grey plover , *Pluvialis squatarola*, E Atlantic/W Africa -wintering 2749 individuals, representing an average of 1.1% of the population (5 year peak mean 1998/9-2002/3)
Stour and Orwell Estuaries SPA	The site qualifies under Article 4.1 of the Birds Directive (2009/147/EC) for supporting the following species: Avocet *Recurvirostra avosetta*, 21 pairs – breeding, 5 year peak mean 1996 – 2000 3.6% of GB population The site qualifies under Article 4.2 of the Birds Directive (2009/147/EC) for supporting the following species:

Site	Qualifying feature screened in
	Redshank *Tringa tetanus* 2,588 individuals – autumn passage 5 year peak mean 1995/96 – 1999/2000 2.0% brittanica Dark-bellied brent goose *Branta bernicla bernicla* 2,627 individuals – wintering 5 year peak mean 1995/96 – 1999/2000 1.2% bernicla, Western Siberia (breeding) Pintail Anas acuta 741 individuals – wintering 5 year peak mean 1995/96 – 1999/2000 1.2% Northwestern Europe (non-breeding) Grey plover *Pluvialis squatarola* 3,261 individuals - Wintering 5 year peak mean 1995/96 – 1999/2000 1.3% Eastern Atlantic (nonbreeding) Knot *Calidris canutus Islandica* 5,970 individuals – wintering 5 year peak mean 1995/96 – 1999/2000 1.3% islandica Dunlin *Calidris alpina alpina* 19,114 individuals – wintering 5 year peak mean 1995/96 – 1999/2000 1.4% alpina, Western Europe (non-breeding) Black-tailed godwit *Limosa limosa islandica* 2,559 individuals - Wintering 5 year peak mean 1995/96 – 1999/2000 7.3% islandica Redshank *Tringa tetanus* 3,687 individuals - Wintering 5 year peak mean 1995/96 – 1999/2000 2.8% brittanica The site qualifies under article 4.2 of the Directive (79/409/EEC) as it is used regularly by over 20,000 waterbirds, including: including great crested grebe *Podiceps cristatus*, cormorant Phalacrocorax carbo, dark-bellied brent goose *Branta bernicla bernicla*, shelduck *Tadorna tadorna*, wigeon *Anas penelope*, gadwall *Anas strepera*, pintail *Anas acuta*, goldeneye *Bucephala clangula*, ringed plover *Charadrius hiaticula*, grey plover *Pluvialis squatarola*, lapwing *Vanellus vanellus*, knot *Calidris canutus islandica*, dunlin *Calidris alpina alpina*, black-tailed godwit *Limosa limosa islandica*, curlew *Numenius arquata*, redshank *Tringa totanus* and turnstone *Arenaria interpres*
Stour and Orwell Estuaries Ramsar	Ramsar criterion 5: Assemblages of international importance: Species with peak counts in winter: 63017 waterfowl (5 year peak mean 1998/99-2002/2003) Ramsar criterion 6: species/populations occurring at levels of international importance. Qualifying Species/populations (as identified at designation): Species with peak counts in spring/autumn: Common redshank , *Tringa totanus totanus*, 2588 individuals, representing an average of 2% of the population (5-year peak mean 1995/96- 1999/2000) Species with peak counts in winter: Dark-bellied brent goose, *Branta bernicla bernicla*, 2627 individuals, representing an average of 1.2% of the population (5-year peak mean 1995/96-1999/2000) Northern pintail , *Anas acuta*, NW Europe 741 individuals, representing an average of 1.2% of the population (5-year peak mean 1995/96- 1999/2000) Grey plover , *Pluvialis squatarola*, E Atlantic/W Africa -wintering 3261 individuals, representing an average of 1.3% of the population (5-year peak mean 1995/96- 1999/2000) Red knot , *Calidris canutus islandica*, W & Southern Africa (wintering) 5970 individuals, representing an average of 1.3% of the population (5-year peak mean 1995/96- 1999/2000) Dunlin , *Calidris alpina alpina*, W Siberia/W Europe 19114 individuals, representing an average of 1.4% of the population (5-year peak mean 1995/96-1999/2000)

Site	Qualifying feature screened in
	Black-tailed godwit, *Limosa limosa islandica*, Iceland/W Europe 2559 individuals, representing an average of 7.3% of the population (5-year peak mean 1995/96-1999/2000) Common redshank, *Tringa totanus totanus*, 3687 individuals, representing an average of 2.8% of the population (5-year peak mean 1995/96-1999/2000)
Colne Estuary (Mid-Essex Coast Phase 2) SPA	The site qualifies under Article 4.1 of the Birds Directive (2009/147/EC) for supporting the following species: Little tern *Sterna albifrons*, breeding - 73 pairs 1987-1991 (3% of British breeding population). Hen harrier *Circus cyaneus*, wintering - 19 birds 1987/88 to 1991/92 (2% of the British total). The site qualifies under Article 4.2 of the Birds Directive (2009/147/EC) for supporting as a wetland of international importance by regularly supporting, in winter, over 20,000 waterfowl, including internationally important numbers of: 5,315 dark-bellied brent geese *Branta bernicla bernicla* (3.1 % of the total world population, 5.9% of the British wintering population) 1,252 redshank *Tringa totanus* (1.1% of the East Atlantic Flyway (EAF) population, 1.6% of British). and nationally important numbers of: 243 cormorant *Phalacrocorax carbo* (1.2% of British), 354 mute swan *Cygnus olor* (1.9% of British), 1,237 shelduck *Tadorna tadorna* 1.6% of British), 262 Goldeneye *Bucephala clangula* (1.7% of British), 355 ringed plover *Charadrius hiaticula* (1.5% of British), 1,168 grey plover *Pluvialis squatarola* (5.5% of British), 219 sanderling *Calidris alba* (1.5% of British), 11,272 dunlin *Calidris alpina* (2.6% of British), 606 black-tailed godwit *Limosa limosa* (12.7% of British) 938 curlew *Numenius arquata* (1% of British). Breeding: 15 pairs (7% of British breeding population) of pochard *Aythya ferina* 135 pairs (1% of British) of ringed plover *Chararius hiaticula*
Colne Estuary (Mid-Essex Coast Phase 2) Ramsar	Ramsar criterion 5: Assemblages of international importance: Species with peak counts in winter: 32041 waterfowl (5 year peak mean 1998/99-2002/2003) Ramsar criterion 6: species/populations occurring at levels of international importance. Qualifying Species/populations (as identified at designation): Species with peak counts in winter: Dark-bellied brent goose, *Branta bernicla bernicla*, 3165 individuals, representing an average of 1.4% of the population (5 year peak mean 1998/9-2002/3) Common redshank , *Tringa totanus totanus*, 1624 individuals, representing an average of 1.3% of the GB population (5 year peak mean 1998/9-2002/3)

4.6 Onshore ecology (Annex I habitats or Annex II species in SACs)

114. There is potential for indirect effects which could result in LSE on the designated Annex II species feature Fisher's estuarine moth *Gortyna borelii lunata* of Hamford Water SAC for the Project alone or in-combination, this site has been screened in to the shadow Appropriate Assessment.

115. All other European sites designated for onshore Annex I habitats or Annex II species are screened out on the basis of no potential for LSE. For further information on the rationale, see Appendix 1.

5 Benthic ecology (Annex I habitat in SACs and SPA supporting habitat)

5.1 Approach to assessment

5.1.1 Consultation

116. The offshore HRA screening was submitted to the relevant Expert Topic Groups (ETGs) on 1st October 2021 and 15th November 2022. The following stakeholders were consulted, and responses received are detailed in Table 3-1 of Appendix 1:

- Natural England;
- Royal Society for the Protection of Birds (RSPB);
- Kent and Essex Inshore Fisheries and Conservation Authority (IFCA);
- Essex Wildlife Trust;
- Environment Agency;
- Marine Management Organisation (MMO); and
- The Wildlife Trusts.

117. Further consultation responses relevant to the RIAA which have been received to date are summarised in Table 5.1.

Table 5.1 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
Natural England	26/05/2021 Written response regarding benthic survey methodology	It is worth noting that should the geophysical survey reveal more potential habitat changes than expected, then we would expect to see an increase in the number of sample stations to ensure that all potential habitats are sampled and mapped. In turn, this will also inform the impact assessment on the full range of habitats. This is particularly important within MPAs.	Additional sample stations were included in the benthic survey in response to feedback from Natural England. The data available from Magic mapper (Natural England, 2022d) are considered in the assessment (Sections 5.2.3 and 5.3.3).
Natural England	26/05/2021 Written response regarding benthic survey methodology	If a development is planned within an MPA, site characterisation also needs to consider potential impacts of the development that extend outside of the MPA, which may require additional survey work to increase confidence and precision on location and extent of the habitats and species present. This might entail more detailed geophysical and/or ground truthing surveys (e.g. video) to assist in locating and defining designated feature boundaries. Therefore, we would recommend that data of a sufficient resolution are gathered in order to clearly understand which features are present and likely to be impacted by the proposals.	
Natural England	26/05/2021 Written response regarding benthic survey methodology	It should be ensured that there are sufficient data captured where the cable route abuts Margate and Long Sands SAC to ensure that impacts on this site can be determined and assessed. These data should be put into context with existing Marine Protected Area data available on Magic mapper or here: Habitat and species open data: https://data.gov.uk/dataset/bfc23a6d-8879- 4072-95ed-125b091f908a/marine-habitats-and-species-open-data	
Natural England	16/08/2021 Scoping Opinion	Section 2.5.1.2 Point 187 Whilst we welcome the offshore export cable route avoiding Margate and Long Sands SAC there still needs to be consideration of potential indirect impacts from site preparation and/or installation activities to the site, and if appropriate suitable mitigation measures need to be adopted. Further consideration to indirect impacts on the SAC should be given throughout the EIA process.	A detailed assessment of the potential effects on the Margate and Long Sands SAC is provided in Section 5.2

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
The Planning Inspectorate	26/08/2021 Scoping Opinion	Para 199 Table 2.10 Designated sites and study areas. Table 2.10 lists the nearest designated sites to the North Falls array areas but does not state the study area(s) that have been applied. The Inspectorate notes that there are several other offshore designated sites within the vicinity of the Proposed Development (as shown on Figure 1.2) and it’s not evident in the report as to why impacts on these sites and their qualifying / protected features have been discounted. The ES should clearly define the study area and explain how the assessment has been undertaken, taking into relevant guidance and using an aspect specific methodology where this is relevant."	Offshore Habitats Regulations Assessment (HRA) screening was undertaken in consultation with the Seabed ETG and is provided in Appendix 1. Section 5.4 of the HRA screening (Appendix 1) details the conservative study area (50km range) used to identify designated sites for consideration in the HRA screening.

5.1.2 Worst case scenario

118. Table 5.2 outlines the worst case scenario for effects which are of relevance to the Appropriate Assessment.

119. As discussed in Section 4.1, an LSE has been identified for the Margate and Long Sands SAC and Outer Thames Estuary SPA supporting habitats as a result of the offshore cable corridor.

120. The North Falls array areas are 2km at the nearest point from the Outer Thames Estuary SPA and 10km from the Margate and Long Sands SAC. The findings of the Marine Geology, Oceanography and Physical Processes impact assessment (PEIR Chapter 8, Volume I) shows suspended sediments will return to the seabed within 1km. Therefore there is no pathway for LSE on Annex I habitats or supporting habitats of European sites from the North Falls array areas, alone or in-combination. The worst case scenario (Table 5.2) therefore relates to effects arising in the offshore cable corridor.

Table 5.2 North Falls worst case scenario relating to seabed effects in the offshore cable corridor

Impact	Worst case	Notes
Construction		
Temporary physical disturbance – offshore cable corridor	Maximum temporary disturbance for seabed preparation within the offshore cable corridor = 6,019,200m^2 based on: • Maximum total offshore export cable trench length of 250.8km. • Maximum width of temporary disturbance is approximately 24m • Anchor placement = 297,826m^2 • Boulder clearance = 295m^2 (up to 15 boulders of 5m diameter) • HDD exit – 4 offshore export cables exiting in 1 to 8m water depth Total disturbance footprint – 6.32km^2. There will be no direct disturbance in the Margate and Long Sands SAC Of the above works, the following could be within the Outer Thames Estuary SPA Maximum temporary disturbance for seabed preparation within the offshore cable corridor = 1,827,840m^2 based on: • Maximum total offshore export cable trench length of 76.16km. • Maximum width of temporary disturbance is approximately 24m • Anchor placement = 90,440m^2 • Boulder clearance = 295m^2 (up to 15 boulders of 5m diameter) Total disturbance footprint – 1.92km^2.	As above, temporary disturbance relates to seabed preparation and Installation activities. The long term/ permanent footprint of infrastructure is assessed as an operation phase impact
Increased suspended sediment concentration (SSC) – offshore export cable installation	Offshore export cable seabed preparation – 250.8km length with average 24m disturbance width x average 5m sediment depth = 30,096,000m^3 Offshore export cable burial – 250.8km length with average 1m trench width x average 1.2m burial depth = 300,960m^3	

Impact	Worst case	Notes
	Of the above works, the following could be adjacent to the Margate and Long Sands SAC Offshore export cable seabed preparation – 4.8km export cable length with average 24m disturbance width x average 5m sediment depth = 576,000m^3 Offshore export cable burial – 4.8km length with average 1m trench width x average 1.2m burial depth = 5,760m^3 Of the above works, the following could be within the Outer Thames Estuary SPA Offshore export cable seabed preparation – 76.16km length with average 24m disturbance width x average 5m sediment depth = 9,139,200m^3 Offshore export cable burial – 76.16km length with average 1m trench width x average 1.2m burial depth = 91,392m^3	
Remobilisation of contaminated sediments	Maximum suspension of sediments as described above. No significant contaminated sediments were recorded in the offshore project area.	
Operation & maintenance (O&M)		
Temporary physical disturbance	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: • Reburial of c. 5km of offshore export cable is estimated over the life of the project (24m disturbance width) = 120,000m^2 • Four offshore export cable repairs are estimated over the project life. 600m section removed x 24m disturbance width = 57,600m^2 Anchored vessels placed during the no. of cable repairs include above = 2,184m^2 Total footprint of temporary physical disturbance during maintenance = 179,784m^2 There will be no direct disturbance in the Margate and Long Sands SAC Of the above works, as a worst case scenario, all the works could be within the Outer Thames Estuary SPA.	Each O&M activity would be relatively short term and it is likely that the requirements for maintenance would be spread over the project life, with recovery commencing once the activity is complete.
Permanent/ long term habitat loss – offshore cable corridor	Offshore export cable protection - Up to 25km of cable protection may be required in the unlikely event that offshore export cables cannot be buried (based on 10% of the length) x 6m cable protection width = 150,480m^2 There will be no direct habitat loss in the Margate and Long Sands SAC Of the above works, as a worst case scenario, all the works could be within the Outer Thames Estuary SPA.	
Suspended sediment	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: • Reburial of c. 5km of offshore export cable is estimated over the life of the project (24m disturbance width) x average 1.2m depth = 144,000m^3 • Four offshore export cable repairs are estimated over the project life. 600m section removed x 24m disturbance width x average 1.2m depth = 69,120m^3	Each O&M activity would be relatively short term and it is likely that the requirements for maintenance would be spread over the project life, with suspended

Impact	Worst case	Notes
	Of the above works, as a worst case scenario, all the works could be within the Outer Thames Estuary SPA or adjacent to the Margate and Long Sands SAC.	sediments becoming rapidly redeposited.
Remobilisation of contaminated sediments	Maximum suspension of sediments as described above. No significant contaminated sediments were recorded in the offshore project area. See Chapter 9 Marine Water and Sediment Quality (PEIR Volume I) for more detail.	
Decommissioning		
No decision has yet been made regarding the final decommissioning policy for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. Offshore cables may be removed or left in situ; and Cable protection is likely to be decommissioned in situ. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator. For the purposes of the worst-case scenario, it is anticipated that the impacts will be no greater than those identified for the construction phase.		

5.1.3 Embedded mitigation

121. This section outlines the embedded mitigation relevant to works in the offshore cable corridor, which has been incorporated into the design of North Falls (Table 8.2).

Table 5.3 Embedded mitigation measures

Parameter	Mitigation measures embedded into North Falls design
Offshore cable corridor	The offshore cable corridor was selected in consultation with key stakeholders to select a route which minimised impacts on designated sites, such as avoiding direct impacts on Margate and Long Sands SAC.
Electromagnetic Fields (EMF)	The Applicant is committed to burying offshore export cables where practicable which reduces the effects of EMFs.
Micrositing	Should seabed obstacles (e.g. *Sabellaria* reef) be identified in the proposed cable route during the pre-construction surveys, micrositing would be undertaken where practicable, to minimise potential impacts
Invasive Non-Native Species (INNS)	The risk of spreading INNS will be reduced by employing biosecurity measures in accordance with the following requirements: • International Convention for the Prevention of Pollution from Ships (MARPOL). The MARPOL sets out appropriate vessel maintenance; • The International Convention for the Control and Management of Ships' Ballast Water and Sediments, which provide global regulations to control the transfer of potentially invasive species; and • The Environmental Damage (Prevention and Remediation (England) Regulations 2015, which set out a polluter pays principle where the operators who cause a risk of significant damage or cause significant damage to land, water or biodiversity will have the responsibility to prevent damage occurring, or if the damage does occur will have the duty to reinstate the environment to the original condition.

5.2 Margate and Long Sands SAC

5.2.1 Site overview

122. Margate and Long Sands SAC has been designated for Annex I habitat: 'Sandbanks which are slightly covered by seawater at all times'. The site

accounts for 2-15% of the national Annex I sandbank resource and represents one of the greatest areas of sandbanks in the UK. It is located to the north of the Thanet coast of Kent, and spans in a north-easterly direction for approximately 62km (Natural England, 2018a).

123. The sandbanks are composed of sandy sediments upon the crests and muddier, more gravelly sediments in the troughs between banks. The boundary of the site incorporates the flanks of the banks and the intervening troughs. The troughs have been included in the site designation as they are important for the structure and function of the sandbanks and provide suitable habitat for notable faunal communities.

124. Within the SAC there are areas of varying sediment type, salinity and exposure to tides and wave action, ultimately supporting different associated biological communities.

125. Long Sands sandbank is located in a highly dynamic, tidally influenced estuary mouth. Subsequently, it is heavily influenced by currents from the North Sea.

5.2.2 Conservation objectives

5.2.2.1 Overview

126. Conservation objectives are set to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving FCS of its qualifying features, by maintaining or restoring (Natural England, 2018a):

- The extent and distribution of qualifying natural habitats;
- The structure and function (including typical species) of qualifying natural habitats; and
- The supporting processes on which the qualifying natural habitats rely.

127. The Conservation Objectives for the Margate and Long Sands SAC is to maintain the Annex I Sandbanks which are slightly covered by seawater all the time in Favourable Condition. In particular the sub-features (Joint Nature Conservation Committee (JNCC) and Natural England, 2012b):

- Dynamic sand communities
- Gravelly muddy sand communities

128. ‘Favourable Condition’ is the term used in the UK to represent ‘Favourable Conservation Status’ for the interest features of SACs. For an Annex I habitat, Favourable Conservation Status occurs under the Habitats Directive when (JNCC and Natural England, 2013):

- Its natural range and areas it covers within that range are stable or increasing;
- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future; and
- The conservation status of its typical species is favourable.

129. The assessment of the potential effects on the Annex I Sandbank feature is based on the following targets set by JNCC and Natural England (2012) for achieving Favourable Condition:

- No decrease in extent from established baseline, subject to natural succession/known cyclical change.
- Consideration of changes in extent will need to take account of the dynamic nature of the sandbank.
- No alteration in topography of the sandbanks, allowing for natural responses to hydrodynamic regime.
- The depth and distribution of the sandbanks reflects the energy conditions and stability of the sediment, which is key to the structure of the feature. However, it should be noted that subtidal sandbanks are naturally dynamic environments and sections of them may be subject to significant fluctuations in height over time, while other sections are more stable.
- Maintain distribution of dynamic and stable sand and mixed sediments allowing for natural fluctuations. Average particle size analysis parameters should not deviate significantly from the baseline established for the sites, subject to natural change.
- Sediment character is key to the structure of the sandbank, and reflects the physical processes acting on it. In addition to this, the sediment character is instrumental in determining the biological communities present on the sandbank.
- Maintain the distribution of subtidal sandbank communities, allowing for fluctuation.
- Notable biotopes should be selected owing to their national significance, sensitivity, or how representative it is as a typical biotope for the biological zone.
- Where a biotope is lost from a baseline known area of presence (outside expected natural variation), leading to a loss of the conservation interest of the site, then condition should be considered unfavourable.
- Changes in the presence or distribution of biotopes may indicate long-term changes in the physical conditions at the site, and deterioration in the overall biological value of the site.
- No decline in biotope quality as a result of reduction in species richness or loss of species of ecological importance, allowing for fluctuation.
- Whilst some change in community composition over time is expected (for example, as part of cyclic changes or successional trends) changes in the overall nature of communities across the key representative biotopes sandbank, may indicate deterioration in the condition of the biodiversity of the sandbanks.
- Species composition is an important contributor to structure of a biotope. The presence and abundance of a characterising species gives an indication of the quality of a biotope, and any change in composition may indicate a cyclic change or trend in the sandbank community. Where

changes in species composition are known to be clearly attributable to natural succession, known cyclical change or mass recruitment or dieback of characterising species, then the target value should accommodate this variability. Where there is a change in biotope quality outside the expected variation or a loss of the conservation interest of the site, then condition should be considered unfavourable.

- Maintain age/size class structure of individual species.
- Changes in presence and/or abundance of a species can critically affect the physical and functional nature of the habitat, leading to unfavourable condition. The species selected should serve an important role in the structure and function of the biological community.
- Whilst some change in community structure over time is expected (for example, as part of the cyclic changes or successional trends) changes in the overall nature of communities across the sandbank, including mobile species e.g. fish, crustacean species etc, may indicate deterioration in the condition of the biodiversity of the sandbanks.
- Where the field assessment judges changes in the presence and/or abundance of specified species to be unfavourable, and subsequent investigation reveals the cause is clearly attributable to natural succession and known cyclical change (such as mass recruitment and dieback of characterising species), the final assessment will require expert judgement by Natural England advisers to determine the reported condition of the feature. The features condition could be declared favourable where the expert judgement of Natural England/JNCC advisers is certain that the conservation interest of the feature is not compromised by the failure of this attribute to meet its target condition. Where there is a change outside the expected variation or a loss of the conservation interest of the site, (e.g. due to anthropogenic activities or unrecoverable natural losses) then condition should be considered unfavourable.

5.2.2.2 Management measures

130. There is currently a byelaw in place to prevent deterioration of the sandbank feature of Margate and Long Sands SAC from the direct impacts of bottom towed fishing (MMO, 2017).

131. As there is no overlap between the SAC and the offshore cable corridor there will be no direct impact on the areas protected by the management areas of the byelaw during the construction, O&M or decommissioning of North Falls. Consequently, there are no specific management measures in place for activities related to the construction, O&M or decommissioning of North Falls.

5.2.2.2.1 Supplementary Advice on Conservation Objectives

132. Natural England have prepared conservation advice for the SAC (Natural England, 2012b). This advice identifies six pressure categories which may cause deterioration of sandbank habitats within SACs, either alone or in combination and thus affect Favourable Condition. These have been identified as:

- Physical loss;
- Physical damage;

- Non-physical disturbance;
- Toxic contamination;
- Non-toxic contamination; and
- Biological disturbance.

133. The sensitivity, exposure and vulnerability of Annex I Sandbank features of the Margate and Long Sands SAC to the above pressures is provided in Table 5.4.

Table 5.4 Sensitivity, exposure and vulnerability of Annex I Sandbank features (Natural England, 2012b)

Operations which may cause deterioration or disturbance	Annex I Subtidal sandbanks					
	Dynamic sand communities			Gravelly muddy sand communities		
	Sensitivity	Exposure	Vulnerability	Sensitivity	Exposure	Vulnerability
Physical loss						
Removal	Moderate	Medium	Moderate	Moderate	Medium	Moderate
Smothering	Low	Medium	Low	Low	Medium	Low
Physical damage						
Siltation	Low	Medium	Low	Low	Medium	Low
Abrasion	Low	Medium	Low	Moderate	Medium	Moderate
Selective extraction	Low	Low	Low	Low	Low	Low
Non-physical disturbance						
Noise	None	None	None	None	None	None
Visual	None	None	None	None	None	None
Toxic contamination						
Introduction of synthetic compounds	Moderate	Low	Low	Moderate	Low	Low
Introduction of non-synthetic compounds	Moderate	Low	Low	Moderate	Low	Low
Introduction of radionuclides	Insufficient information	Low	Insufficient information	Insufficient information	Low	Insufficient information
Non-toxic contamination						
Changes in nutrient loading	Moderate	Low	Low	Low	Low	Low
Changes in organic loading	Moderate	Low	Low	Moderate	Low	Low
Changes in thermal regime	Low	Low	Low	Low	Low	Low
Changes in turbidity	Low	Low	Low	Low	Low	Low
Changes in salinity	Moderate	Low	Low	Low	Low	Low

Operations which may cause deterioration or disturbance	Annex I Subtidal sandbanks					
	Dynamic sand communities			Gravelly muddy sand communities		
	Sensitivity	Exposure	Vulnerability	Sensitivity	Exposure	Vulnerability
Biological disturbance						
Introduction of microbial pathogens	None	None	None	Low	None	None
Introduction of non-native species and translocation	None	Medium	Moderate	Low	Medium	Low
Selective extraction of species	Low	Medium	Low	Low	Medium	Low

5.2.3 Shadow Appropriate Assessment

134. As discussed in Section 4 and Appendix 1, the Margate and Long Sands SAC is located adjacent to the offshore cable corridor and therefore this section provides the shadow Appropriate Assessment for the designated feature, Annex I Sandbanks which are slightly covered by seawater all the time.

5.2.3.1 Potential effects during construction

5.2.3.1.1 Changes to suspended sediment concentrations and bedload transport

135. PEIR Chapter 8 Marine Geology, Oceanography and Physical Processes (Volume I) provides details of increased SSC and subsequent sediment deposition, and changes to bedload sediment transport as a result of the Project.

136. Based on the worst case scenario, approximately 576,000m^3 of sediment would be re-mobilised into the water column during seabed preparation and 5,760m^3 during cable burial adjacent to the Margate and Long Sands SAC.

The extent and distribution of qualifying habitat

137. Chapter 8 of the PEIR Marine Geology, Oceanography and Physical Processes (Volume I) describes the expected movement of sediment suspended during the construction phase for the above offshore export cable installation activities.

138. Fine sands and mud are most prevalent along the offshore cable corridor and within the SAC. Fine sand and mud is likely to form a passive plume which would become advected by tidal currents. Due to the sediment sizes present, this is likely to exist as a measurable but modest concentration plume. Sediment would settle to the seabed in proximity to its release (within a few hundred metres up to around 1km) within a short period of time (hours to days), however magnitudes would be indistinguishable from background levels.

139. As the disturbed sediment arising from within the offshore cable corridor is similar to the sediment composition within the SAC, there will be no significant change to the extent and distribution of the Annex I Sandbank habitat within the SAC upon settlement. Therefore, there is no potential for an AEoI of this attribute due to increased SSC and subsequent deposition.

Supporting processes

140. Chapter 8 of the PEIR Marine Geology, Oceanography and Physical Processes (Volume I) describes the effects on bedload sediment transport and suspended sediment resulting from sandwave levelling and cable installation.

141. The dredged sand will be disposed of within the offshore project area, as close as possible to the location of origin and will therefore remain within the sandbank system. Given the local favourable conditions that enable sandwave development in the study area, the sediment would be naturally transported back into any levelled areas within a short period of time. Levelled areas will naturally act as a sink for sediment in transport and will be replenished in the order of a few days to a year.

142. For Galloper Wind Farm (GWF), a plume modelling simulation was carried out which indicated that suspended sediment would persist in the water column for hours to days, before depositing a thin layer on the seabed. Overall changes from SSC and deposition of fine sands and mud-sized sediment will not be measurable above background levels (Chapter 8 of the PEIR. Volume I).

143. Therefore, there is no potential for an AEoI of this attribute due to increased SSC, sediment deposition and bedload sediment transport processes.

Structure and function of sandbank communities

144. Increased suspended sediments have the potential to affect benthic ecology receptors by blocking feeding apparatus as well as by smothering sessile species upon redeposition. Therefore, there is potential for increased SSC and subsequent deposition to affect sandbank benthic and fish communities within the SAC due to seabed preparation and cable installation.

145. The sandbanks within the Margate and Long Sands SAC consist of the following sub-features (Natural England, 2012b):

- Dynamic sand communities; and
- Gravelly muddy sand communities.

146. Dynamic sand communities experience strong tidal currents and consequently there is high sediment mobility. In turn, infaunal communities are adapted to suspended sediment and deposition, for example, by rapidly re-burying themselves following disturbance. Characteristic species of this sub-feature are polychaetes and amphipod communities of low biodiversity.

147. Gravelly muddy sand communities are identified on the flanks of sandbanks. There is reduced sediment movement within these communities allowing for a range of infaunal and epifaunal species and more diverse communities. Characteristic species include bryozoans, hydroids and sea anemones. Sand mason worms *Lanice conchilega* and keel worms *Pomatoceros* sp. along with bivalves and crustaceans are also associated with this sub-feature (Natural England, 2012b).

148. Sample data ranging from 2008 to 2014 (shown in Natural England, 2022d) recorded subtidal sand (European Nature Information System (EUNIS) habitat A5.2) in the northern extent of the SAC, including:

- *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (A5.261); and
- *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (A5.242).

149. The results of the 2021 North Falls benthic survey conducted by Fugro (PEIR Appendix 10.1, Volume III) correlated well with this data, with the following biotopes recorded in the northern extent of the SAC:

- *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (A5.261); and
- Infralittoral coarse sediment (A5.13).

150. In the 2021 survey no *S. spinulosa* aggregations were reported in the offshore cable corridor or the northern extent of the SAC. During a 2014 survey of Margate and Long Sands SAC by Natural England, Sabellaria reef was recorded approximately 4km from the offshore cable corridor (data accessed in Natural England, 2022d). Natural England (2012) states that, while a significant amount of *S. spinulosa* is present in the SAC, Sabellaria reef was not included as a designated feature of the SAC, as the distribution was patchy and aggregations were typically present in crust form rather than Annex I reef.

151. Both dynamic sand communities and gravelly muddy sand communities have low sensitivity to suspended sediment and smothering (Natural England, 2012b). While Sabellaria reef is not currently recorded within the zone of influence, it is ephemeral and so has potential to become established. This receptor is not sensitive to suspended sediment and smothering.

152. Based on the low sensitivity of benthic communities and the effects from SSC causing indistinguishable change to background levels, there is no potential for an AEoI of this attribute due to increased SSC and subsequent deposition during construction.

5.2.3.1.2 Smothering

153. The effects of smothering are closely related to increased SSC and have been discussed above in Section 5.2.3.1.1. In summary, as the disturbed sediment arising from within the offshore cable corridor is similar to the sediment composition within the SAC and the communities present are of low sensitivity to smothering, there will be no AEoI of this attribute due to smothering.

5.2.3.1.3 Re-mobilisation of contaminated sediments

154. The re-suspension of sediment during seabed preparation and the installation of cables within the offshore cable corridor could lead to the release of contaminated sediment which may have an effect on benthic biological communities associated with the protected features of the SAC.

155. To inform the baseline for sediment quality, a benthic survey of the offshore development areas was undertaken between May and August 2021 where grab sampling was undertaken and samples analysed for the following chemical contaminants:

- Trace metals;
- Polyaromatic Hydrocarbons (PAHs); and

- Polychlorinated Biphenyls (PCBs).

156. Chemical analysis was undertaken by SOCOTEC, in line with the MMO accreditation scheme regarding sediment sampling for disposal at sea licensing.

157. The context of contaminants found within sediments is established through the use of recognised guidelines and action levels, in this case Cefas Action Levels have been applied because they provide good coverage of contaminants, across a broad range of contaminant types (MMO, 2018). These levels are used to indicate general contaminant levels in the sediments. If, overall, levels do not generally exceed the lower threshold values of these guideline standards, then contamination levels are not considered to be of significant concern and are low risk in terms of potential impacts on the marine environment.

158. A comparison of the sediment quality data against Cefas Action Levels has been undertaken in Chapter 9 Marine Water and Sediment Quality of the PEIR (Volume I). PEIR Chapter 9 concludes that sediment contamination levels are not of significant concern and are low risk in terms of potential impacts on the marine environment. Even though there are some elevated levels of contaminants within the sediments, they align with the typical levels for the region and do not pose a high risk.

159. Based on the absence of contaminants at levels of concern recorded within the North Falls offshore cable corridor, it can be concluded that there is no potential for an AEoI due to re-mobilisation of contaminated sediments during construction.

5.2.3.2 Potential effects during operation

5.2.3.2.1 Changes to suspended sediment concentrations and bedload transport

160. Increases in SSC in the water column and subsequent deposition onto the seabed may occur during O&M activities. Potential activities include reburial and repairs to the offshore export cables.

161. Each O&M activity would be relatively short term and it is likely that the requirements for maintenance would be spread over the project life, with suspended sediments becoming rapidly deposited. Four offshore export cable repairs are estimated over the project life, with the location of these repairs unknown. As a worst case scenario, it is assumed that all works could be adjacent to the Margate and Long Sands SAC.

162. In addition, surface laid cable protection has potential to influence sediment transport. Cables will be buried where possible, however, as a worst case scenario, it has been assumed that cable protection measures would need to be provided to surface-laid cables e.g. in areas of hard substrate and cable crossings. An estimate of 10% of the cable length requiring cable protection is included in the worst case scenario (Section 5.1.2). While it is likely that cables adjacent to the Margate and Long Sands SAC would be buried, as a worst case scenario, the presence of cable protection adjacent to the northern boundary of the SAC is assessed. Cable protection height would be up to 1.4m and water depths in the offshore cable corridor to the north of the SAC are approximately 18m to 30m.

The extent and distribution of qualifying habitat

163. As with construction (Section 5.2.3.1.2), suspended sediment arising from maintenance activities would be indistinguishable from background levels. In addition, works would be relatively short term in duration and small-scale.

164. Therefore, there is no potential for an AEoI of this attribute due to increased SSC and subsequent deposition during operation.

Supporting processes

165. In areas of active sediment transport, any linear protrusion on the seabed could potentially have an effect on sediment transport.

166. Where the seabed is composed of mobile sand, it can be transported under existing tidal conditions. If the cable protection does present an obstruction to this bedload transport the sediment would first accumulate one side or both sides of the obstacle (depending on the gross and net transport at that location) to the height of the protrusion. With continued build-up, it would then form a 'ramp' over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the offshore export cables would therefore not be impacted significantly. There would therefore be no potential for an AEoI of this attribute due to increased SSC and subsequent deposition during the operational phase.

Structure and function of sandbank communities

167. Maintenance works in the offshore cable corridor have potential to affect benthic communities within the SAC. As described in Section 5.2.3.1.1, sandbank communities within the SAC have low sensitivity to siltation and smothering (Natural England, 2012b).

168. Each O&M activity would be relatively short term and it is likely that the requirements for maintenance would be spread over the project life, with suspended sediments becoming rapidly redeposited in close vicinity to the works.

169. Based on the low sensitivity of benthic communities and the effects from SSC causing indistinguishable change to background levels, it can be concluded that there is no potential for an AEoI of this attribute due to increased SSC and subsequent deposition during the operational phase.

5.2.3.2.2 Smothering due to increased suspended sediment

170. As discussed in Section 5.2.3.1.2, the effects of smothering are closely related to those of increased SSC. The effects of increased SSC have been discussed above in Section 5.2.3.2.1 and due to O&M activities causing an indistinguishable change from background levels, combined with the low sensitivity of benthic communities to smothering, it can be concluded that there will be no AEoI of this attribute due to smothering.

5.2.3.2.3 Re-mobilisation of contaminated sediments

171. As discussed in Section 5.2.3.1.3, sediment analysis carried out by SOCOTEC found no significant levels of contaminants in the offshore project area and so there is no potential for an AEoI due to re-mobilisation of contaminated sediments during maintenance.

5.2.3.3 Potential effects during decommissioning

172. A decision regarding the final decommissioning policy is yet to be decided as it is recognised that rules and legislation change over time in line with best industry practice. The decommissioning methodology and programme would need to be finalised nearer to the end of the lifetime of the Project to ensure it is in line with the most recent guidance, policy and legislation.

173. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in PEIR Chapter 5 Project Description (Volume I) and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of some or all of the export cables. Scour and cable protection would likely be left in situ.

174. During the decommissioning phase, there is potential for cable removal activities to cause effects that would be comparable to those identified for the construction phase (Section 5.2.3.1), specifically:

    - Changes to suspended sediment concentrations;
    - Smothering due to increased suspended sediment
    - Re-mobilisation of contaminated sediments

175. Sediment transport effects associated with cable protection, if left in situ, would remain as assessed for the operational phase (Section 5.2.3.2.1).

176. The decommissioning effects will be comparable to or less than the construction and operational phase. Therefore, an AEoI can be ruled out.

5.2.3.4 Effect of project alone

177. With no potential for an AEoI of the attributes discussed above, an AEoI of the SAC can therefore be ruled out.

5.2.3.5 In-combination effects

178. The in-combination assessment considers other developments (plans or projects) in planning, construction or operation where the predicted effects on the Margate and Long Sands SAC may have the potential to interact with effects from the proposed construction, O&M or decommissioning of North Falls.

179. Plans and projects within the 50km search area have been identified are listed below in Table 5.5.

Table 5.5 Summary of plans and projects considered for the in-combination assessment in relation to the SAC

Plan or project	Status	Construction period	Closest distance to the SAC (km)	Confidence in data	Included in the in-combination assessment	Rationale
NeuConnect Interconnector	Pre-construction	2022-2028	0	High	Yes	The NeuConnect Interconnector bisects the North Falls offshore cable corridor and the SAC so there is potential for temporal overlap of cable installation activities.
BritNed Interconnector	Operational since 2009	N/A	0	High	No	The BritNed Interconnector passes through the SAC but has been operational since 2009. Therefore this is part of the baseline.
Nautilus Interconnector	Pre-application	2025-2028	Cable route unknown	Low	Yes (Subject to available information)	The offshore study area for Nautilus intersects with the North Falls offshore project area, Therefore, there is potential for in-combination effects, subject to the final location and programme for the interconnector.
Sea Link	Pre-application	2026-2030	Cable route unknown	Medium	Yes, for offshore construction effects only (Subject to available information)	The emerging preferred and alternative routes for Sea Link intersect with the North Falls offshore cable corridor. Therefore,

Plan or project	Status	Construction period	Closest distance to the SAC (km)	Confidence in data	Included in the in-combination assessment	Rationale
						there is potential for in-combination effects, subject to the final location and programme for the interconnector.
Tarchon Energy Interconnector	Pre-planning	Unknown	Cable route unknown	N/A	Yes (Subject to available information)	Interconnector between UK and Germany with potential to be in proximity to the North Falls offshore project area.
GGOW	Operational since 2012	N/A	11.34	Medium	No	Both GGOW and GWF are operational and beyond the zone of influence for the SAC, therefore there is no potential in-combination effect on the SAC.
GWF	Operational since 2018	N/A	18.02	Medium	No	
Five Estuaries OWF	In planning	Unknown	0	Medium	Yes	The Five Estuaries offshore cable corridor follows a similar route to the North Falls offshore cable corridor and is expected to have a similar construction programme.
East Anglia TWO OWF	Consent granted	Construction planned mid 2020s	39.03	High	No	Beyond the zone of influence for the SAC.
Thanet OWF	Operational since 2010	N/A	6.87	Medium	No	

Plan or project	Status	Construction period	Closest distance to the SAC (km)	Confidence in data	Included in the in-combination assessment	Rationale
Gunfleet Sands OWF	Operational since 2010	N/A	12.49	Medium	No	Both OWFs are beyond the zone of influence for the SAC.
London Array OWF	Operational since 2013	N/A	0	Medium	No	London Array has been operational since 2013 and is therefore part of the existing conservation status of the SAC.
Outer OTE aggregate exploration and option are 528/2	Unknown	N/A	7.88	Low	No	Due to distance from the SAC there will be no AEoI of the site from temporal overlap of dredging / aggregate exploration and the Project.
East Orford Ness aggregate exploration and option area 1809	Unknown	N/A	25.85	Low	No	
Thames D aggregates production agreement area 524	Production agreement secured 2022	2022-2036	20.09	Low	No	
Southwold East aggregates production agreement area 430	Operational since 2012	N/A	49.45	Medium	No	
North Inner Gabbard aggregate production area 498	Operational since 2015	N/A	25.11	Medium	No	
Shipwash aggregate production agreement area 507	Operational since 2016	N/A	10.88	Medium	No	
North Falls East aggregate production agreement area 501	Operational since 2017	N/A	35.50	Medium	No	

Plan or project	Status	Construction period	Closest distance to the SAC (km)	Confidence in data	Included in the in-combination assessment	Rationale
Longsand aggregate production agreement area 508	Operational since 2014	N/A	0	Medium	Yes	There is potential for some interaction between dredging and aggregate exploration on the SAC. Removal of sediment and sediment plumes have the potential to have an in-combination effect.
Longsand aggregate production agreement area 509	Operational since 2015	N/A	0	Medium	Yes	
Longsand aggregate production agreement area 510	Operational since 2015	N/A	0	Medium	Yes	

180. There is potential for a temporal and spatial interaction during the construction and maintenance of the NeuConnect, Nautilus, Sea Link and Tarchon Energy Interconnectors, the Five Estuaries export cables and the North Falls offshore export cables. In addition, ongoing aggregate production is licenced within the SAC (areas 508, 509 and 510). This could result in an in-combination effect from temporary physical disturbance and increased SSC with subsequent deposition.

181. Finer sand and mud that is present in the suspended sediment are likely to form a passive plume which would become advected by tidal currents. Due to the sediment sizes present this is likely to exist as a measurable but modest concentration plume for around half a tidal cycle (up to six hours). Sediment would eventually settle to the seabed in proximity to its release (within a few hundred metres up to around 1km) within a short period of time (hours to days). SSCs with a lower particle size would extend further from the site of construction activity however magnitudes would be indistinguishable from background levels. Changes to seabed levels are estimated to have minimal change of <1mm and be indistinguishable from background levels.

182. While it is unlikely that all cables would be installed within the zone of influence of the SAC at the same time, if a temporal and/or spatial overlap occurred between the projects, there would not be an AEoI of the Margate and Long Sands SAC in relation to indirect effects of SSCs and smothering. This is due to the similarity in sediment composition of potential SSCs from the likely zone of influence of projects screened in to the Cumulative Effects Assessment (CEA), compared to the sediments found within the SAC. Therefore, should the in-combination effect increase the SSC at any one time and/or increase the duration over which the effects occur, the change to the form and function of the Sandbank feature of the SAC would still be indistinguishable. Furthermore, the benthic communities within the SAC are not sensitive to the effects of smothering and therefore an increase in SSC and subsequent deposition will not have an AEoI of the SAC.

5.3 Outer Thames Estuary SPA supporting habitat

5.3.1 Site overview

183. Details of the ornithological features of the SPA are discussed in Section 1187.

184. With regards to the supporting benthic habitats of the SPA, Natural England has identified five benthic habitats as the supporting features of the SPA. These are shown in Table 5.6 with the extent of each within the SPA.

Table 5.6 Supporting habitats of the SPA

Habitat type	Extent within the SPA (ha)
Subtidal coarse sediment	73,606.64
Subtidal sand	220,295.55
Subtidal mud	12,549.14
Subtidal mixed sediment	62,100.63
Circalittoral rock	335.2

5.3.2 Conservation objectives

185. The conservation objectives for the Outer Thames Estuary SPA are as follows (Natural England, 2019a):

"*With regard to the SPA and the individual species and/or assemblages of species for which the site has been classified (the 'Qualifying Features' listed below), and subject to natural change;*

Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

- The extent and distribution of the habitats of qualifying features
- The structure and function of the habitats of qualifying features
- The supporting processes on which the habitats of the qualifying features rely
- The population of each of the qualifying features, and,
- The distribution of the qualifying features within the site."

186. Further detail on these objectives is provided in the Supplementary Advice which was updated in September 2019 (Natural England, 2019b). Table 5.7 lists out the attributes and targets associated with the conservation objectives relating to the habitats of the SPA, and also provides a screening of which of these attributes are considered for further assessment. For those attributes screened out it is considered that there is no potential for LSE from the Project.

Table 5.7 Conservation objectives: Attributes and targets for supporting habitats of the Outer Thames Estuary SPA and effect screening

Attribute	Target	Screened in / out
Supporting habitat: air quality	Maintain concentrations and deposition of air pollutants at below the site-relevant Critical Load or Level values given for this feature of the site on the Air Pollution Information System (www.apis.ac.uk).	Screened out. Offshore air quality is not relevant to benthic habitats.
Supporting habitat: conservation measures	Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.	Screened in.
Supporting habitat: extent and distribution of supporting habitat for the non-breeding season	Maintain the extent, distribution and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of the non-breeding/wintering period (moulting, roosting, loafing, feeding) at the following levels: Subtidal sand (220,295.55); Subtidal coarse sediment (73,606.64); Subtidal mixed sediments (62,100.63 ha); Subtidal mud (12,549.14 ha); Circalittoral rock (335.2 ha); and Water column.	Screened in. Note however that the 'water column' habitat is not screened in as there is no pathway for seabed effects of the Project to change the extent and distribution of the overlying waters as there will be no infrastructure in the water column or at the surface within the SPA.
Supporting habitat: food availability (bird)	Maintain the distribution, abundance and availability of key food and prey items (e.g. fish) at preferred sizes.	Screened in.
Supporting habitat: water depth	Maintain the depth of inshore waters currently used as feeding or moulting sites.	Screened out. Changes in depth could only occur where surface laid cable protection is present. At worst 15.05ha of cable protection could be deployed within an area of 392,451.7ha or 0.004% of the entire SPA and this would be in discrete locations and a maximum height of 1.4m above the seabed which has no potential to have an LSE on feeding or moulting.
Supporting habitat: water quality – contaminants	Reduce aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.	Screened in.
Supporting habitat: water quality – dissolved oxygen	Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels.	Screened out. Excessive nutrients and/or high turbidity can lead to a drop in DO, there is no pathway for this effect from the Project as it is not a source of nutrients or high turbidity.

Attribute	Target	Screened in / out
Supporting habitat: water quality – nutrients	Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.	Screened out. There is no pathway for this effect from the Project as it is not a source of nutrients.
Supporting habitat: water quality – turbidity	Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.	Screened in.

5.3.3 Shadow Appropriate Assessment

187. The following section provides a summary of the effects of construction and operation on the supporting habitats of the Outer Thames Estuary SPA in context of the conservation objectives.

188. Other conservation objectives which relate directly to red-throated diver (i.e. population and distribution of red-throated diver) are covered in Section 7.2.3.

5.3.3.1 Potential effects during construction

5.3.3.1.1 Structure, function and supporting processes

189. Chapter 8 of the PEIR Marine Geology, Oceanography and Physical Processes (Volume I) describes the effects on bedload sediment transport from sandwave levelling which may occur within the SPA to prepare the seabed for offshore export cable installation.

190. The dredged sand will be disposed of within the offshore project area, as close as possible to the location of origin and will therefore remain within the sandbank system. Given the local favourable conditions that enable sandwave development in the study area, the sediment would be naturally transported back into any levelled areas within a short period of time. Levelled areas will naturally act as a sink for sediment in transport and will be replenished in the order of a few days to a year.

191. Due to the localised nature of the effect and the likelihood of recovery following construction, there is no potential for an AEoI of this attribute.

5.3.3.1.2 Extent and distribution of supporting habitat

192. The potential effects on the extent and distribution of supporting habitat during construction relate to temporary physical disturbance from seabed preparation and cable burial. The maximum total offshore export cable trench length within the SPA is 76.16km (based on 19.04km x 4 cables) with a maximum width of temporary disturbance approximately 24m. The total maximum temporary disturbance for cable installation is 1,827,840m^2.

193. Table 5.8 shows the areas of each habitat type (European Marine Observation and Data Network (EMODnet), 2022; shown in Figure 5.1) within the area of overlap between the offshore cable corridor and the SPA.

Table 5.8 Habitat types within the offshore cable corridor

Habitat type	Area within offshore cable corridor (ha)	Length of cable overlap (m)
Subtidal coarse sediment	700.83	3.3
Subtidal sand	671	2.8
Subtidal mud	278.94	2.8
Subtidal mixed sediment (including Sabellaria reef)	3,145.66	12.6
Circalittoral rock	N/A	N/A

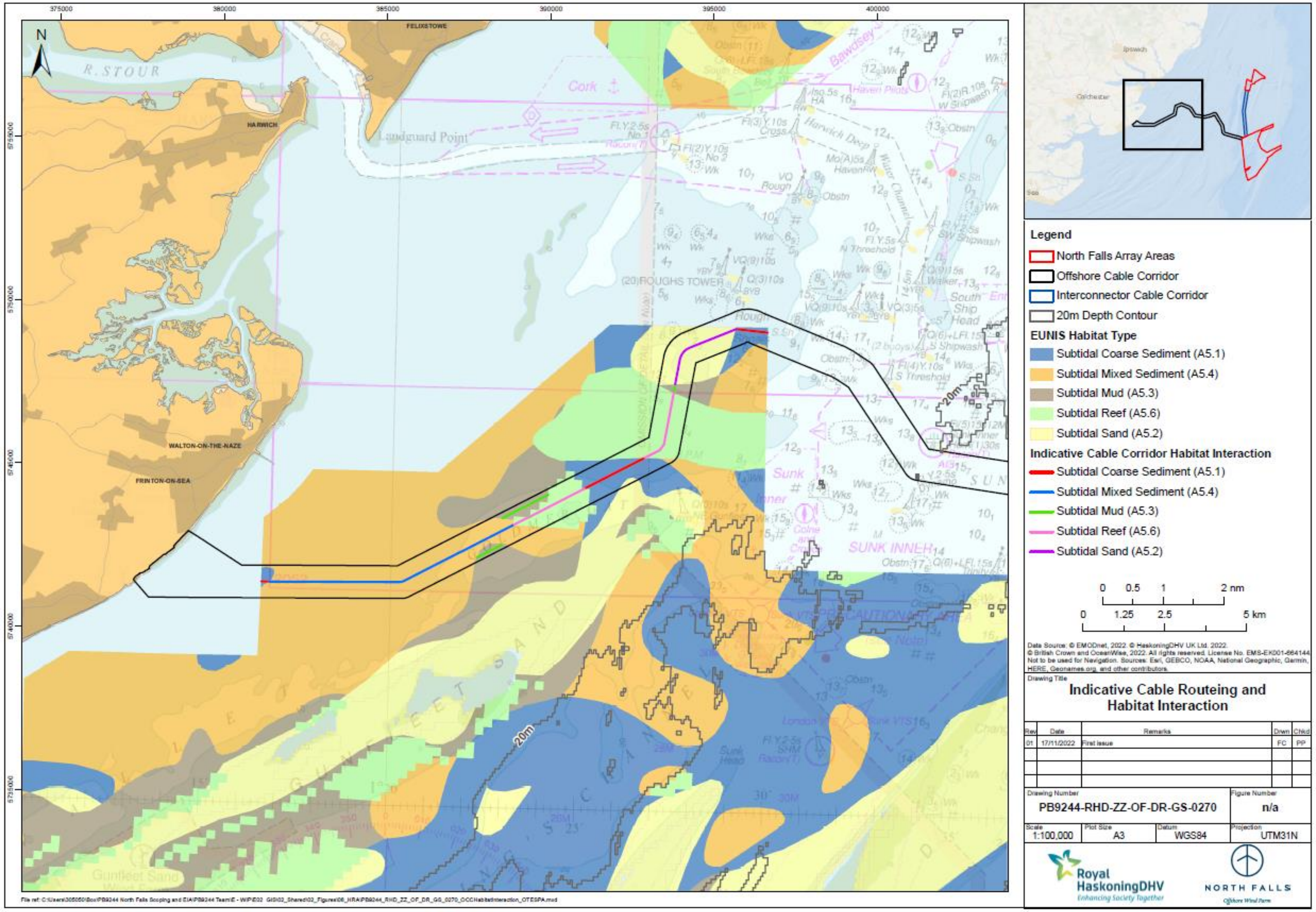

Figure 5.1 Indicative cable routeing and habitat interaction

194. The potential physical disturbance effect on each habitat was then calculated as follows:

- The total length of each habitat type within the SPA and within the offshore cable corridor was calculated by drawing indicative routes within the corridor which intersected with the habitat types.
- These indicative routes were drawn to intersect as much of each habitat type as possible whilst remaining realistic (Figure 5.1).
- The maximum disturbance width of 24m was used to determine the area of effect for each cable
- The length of indicative cable route is all located in waters of <20m depth. Duckworth et al. (2020) show that during foraging, almost all dives by red-throated diver had a maximum dive depth of <20 metres, therefore it is these shallow areas that are considered most relevant as supporting habitat to red-throated diver.

Table 5.9 Effect upon supporting habitat

Habitat Type	Area within SPA (ha)	Length of cable overlap (m)	Effect Area (m^2)	Effect Area (ha)	Effect area as % total habitat type within SPA
Subtidal coarse sediment	73,606.64	3,300 x 4 cables	316,800	31.68	0.04%
Subtidal sand	220,295.55	2,800 x 4 cables	268,800	26.88	0.01%
Subtidal mud	12,549.14	2,800 x 4 cables	268,800	26.88	0.21%
Subtidal mixed sediment	62,100.63	12,600 x 4 cables	1,209,600	120.96	0.19%

195. Table 5.9 shows that in each case, the area is no more than 0.21% of the entire area of the habitat type within the SPA. In the case of subtidal coarse sediment and subtidal sand, only a fraction of the total habitat area potentially affected would be ecologically important to red-throated diver (0.04% and 0.01% respectively).

196. Due to the nature of the sediment and the dynamic physical processes in the area, recovery of the substratum is likely to be rapid in areas which are temporarily disturbed. Given the tolerance and recoverability of the benthic communities present (see PEIR Chapter 10 Benthic and Intertidal Ecology, Volume I), recovery is expected quickly following cessation of installation. A review of post construction monitoring reports from all UK OWFs, for which data was available, has concluded no significant effects on benthic habitats and associated faunal communities due to cable laying (MMO, 2014).

197. Due to the small scale extent of temporary distribution to the supporting habitat, there is no potential AEoI of this attribute.

5.3.3.1.3 Distribution, abundance and availability of prey

198. Red-throated diver mainly forage for fish that live near the surface or in the main water column, although in the winter they will sometimes take bottom-dwelling fish (Natural England, 2012a). Key prey species include sand eels, sprat, flatfish and members of the cod family, and herring being particularly important in the southern North Sea (Natural England, 2019). Their diet can also include crustaceans, molluscs and marine worms (Natural England, 2012a).

199. Table 5.10 presents the overlap of spawning and nursery areas of the species listed above with the SPA and the offshore cable corridor (this is based upon the mapping of spawning and nursery areas presented in the PEIR (Chapter 11 Fish and Shellfish Ecology, Volume I).

Table 5.10 Red-throated diver prey species: Spawning and nursery areas in relation to the SPA (mapping based on Coull et al 1998 and Ellis et al 2010)

Species	Spawning area within SPA	Within offshore cable corridor	Nursery area within SPA	Within offshore cable corridor
Herring	Yes, spawning off Kent.	No	Yes, part of high intensity areas from Norfolk to the English Channel.	Yes
Plaice	Yes, part of high intensity area from across southern North Sea to the English Channel.	No	Yes, low intensity nursery from the Humber to the English Channel.	Yes
Sandeel	Yes, part of low intensity area from across southern North Sea to the English Channel.	Yes	Yes, low intensity nursery across southern North Sea to the English Channel.	Yes
Dover sole	Yes, part of high intensity area from Norfolk to the English Channel.	Yes	Yes, low intensity nursery from the Humber to the English Channel, high intensity nursery within inner Thames.	Yes
Sole	Yes, spawning from across southern North Sea to the English Channel.	Yes	Yes, nursery from across southern North Sea to the English Channel.	Yes
Whiting	No	No	Yes, low intensity nursery across southern North Sea to the English Channel.	Yes
Mackerel	No	No	Yes, low intensity nursery across southern North Sea to the English Channel.	Yes
Cod	Yes, part of low intensity area from across southern North Sea to the English Channel.	Yes	Yes, low intensity nursery across southern North Sea to the English Channel.	Yes
Sprat	Yes, spawning from across southern North Sea to the English Channel.	No	Yes, nursery from across southern North Sea to the English Channel.	Yes

200. For species such as herring and sandeel, the coarser sediment types are favoured habitats (see Appendix 13.1 Fish and Shellfish Ecology Technical Report, Volume III of the PEIR). Whilst the SPA overlaps with areas considered

‘high intensity’ spawning or nursery grounds for certain species (shown in Table 5.10), these areas are vast covering large sections of the North Sea.

201. As shown in Section 5.3.3.1.2, only a limited area of the supporting habitats would be affected temporarily by disturbance during construction within the offshore cable corridor overlapping the SPA. The PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) shows that all effects on fish would be of negligible or low magnitude.

202. Red-throated diver feed opportunistically, exploiting whichever small demersal fish prey are available. Therefore, this small scale temporary change would have no AEoI of this attribute.

203. Disturbance of red-throated diver from potential foraging areas is discussed in Section 1187.

5.3.3.1.4 Contamination

204. As discussed in Section 5.2.3.1.3, sediment analysis carried out by SOCOTEC found no significant levels of contaminants in the offshore project area and so there is no potential for an AEoI due to re-mobilisation of contaminated sediments.

5.3.3.1.5 Maintain natural levels of turbidity

205. The effects of increased SSC have been discussed in Section 5.2.3.1.1 and in PEIR Chapter 8 Marine Geology and Physical Processes (Volume I). It can be concluded that increased SSC during construction activities will be indistinguishable from background levels and would be similar to that of a storm event. Therefore, habitats within the SPA will be tolerant of change in SSC and there will be no AEoI of this attribute of the supporting habitats.

5.3.3.2 Potential effects during operation

5.3.3.2.1 Structure, function and supporting processes

206. Cables will be buried where possible, however, as a worst case scenario it has been assumed that cable protection measures would need to be provided to surface-laid cables e.g. in areas of hard substrate and cable crossings. An estimate of 10% of the cable length requiring cable protection is included in the worst case scenario (5.1.2).

207. The effect that offshore export cable protection may have on the supporting processes of the Outer Thames Estuary SPA primarily relates to the potential for interruption of sediment transport processes. The seabed in the section of the offshore cable corridor overlapping the Outer Thames Estuary SPA is composed of mobile sand which is transported under existing tidal conditions. If the cable protection does present an obstruction to this bedload transport the sediment would first accumulate one side or both sides of the obstacle (depending on the gross and net transport at that location) to the height of the protrusion. With continued build-up, it would then form a ‘ramp’ over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the offshore export cables would therefore not be affected significantly. There would therefore be no potential for an AEoI of this attribute during the operational phase.

5.3.3.2.2 Extent and distribution of supporting habitat

208. Table 5.11 shows the effect of habitat loss from cable protection on each of the habitat types, using a worst case assumption that all of the required cable protection footprint for the entire offshore cable corridor occurs within each of the habitat types.

209. Table 5.12 shows the effect of temporary disturbance from cable maintenance on each of the habitat types, using a worst case assumption that all of the estimated maintenance for the entire offshore cable corridor (Table 5.2) occurs within each of the habitat types.

Table 5.11 Footprint of habitat loss from cable protection in the SPA

Habitat type	Extent within the SPA (ha)	Maximum area of cable protection (ha)	Effect area as % total habitat type within SPA (%)
Subtidal coarse sediment	73,606.64	15.05	0.02
Subtidal sand	220,295.55	15.05	0.01
Subtidal mud	12,549.14	15.05	0.12
Subtidal mixed sediment	62,100.63	15.05	0.02

Table 5.12 Footprint of cable maintenance disturbance

Habitat type	Extent within the SPA (ha)	Maximum area of disturbance (ha)	Effect area as % total habitat type within SPA (%)
Subtidal coarse sediment	73,606.64	17.98	0.02
Subtidal sand	220,295.55	17.98	0.01
Subtidal mud	12,549.14	17.98	0.14
Subtidal mixed sediment	62,100.63	17.98	0.03

210. As shown in Table 5.11, even with the worst case assumption, the percentage of the area of each habitat lost due to cable protection is less than 0.12% of the entire area of the habitat type within the SPA.

211. With regard to temporary habitat disturbance during potential maintenance, Table 5.12 shows that even with the worst case assumption, the percentage of the area of each habitat lost due to cable protection is less than 0.14% of the entire area of the habitat type within the SPA.

212. Although placement of cable protection would represent permanent habitat loss, this area is small in relation to the overall area of each habitat type. Temporary disturbance from maintenance activities would have a very small footprint and, as with disturbance from construction, recovery is expected quickly following cessation of maintenance activities. There would therefore be no potential for an AEoI of this attribute during the operational phase.

5.3.3.2.3 Distribution, abundance and availability of prey

213. As shown in Section 5.3.3.2.2, a limited area of the supporting habitats would be affected temporarily by disturbance during maintenance or permanently through cable protection. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) concludes that the impacts on fish would be of low magnitude.

214. As with the construction phase (Section 5.3.3.1.3), given that the areas of supporting habitat affected are small relative to the supporting habitat available and red-throated diver feed opportunistically, exploiting whichever prey are available, there would be no AEoI of this attribute during O&M.

215. The effects of displacement of red-throated diver is assessed in Section 7.2.3.1.3.

5.3.3.2.4 Contamination

216. As discussed in Section 5.2.3.1.3, sediment analysis carried out by SOCOTEC found no significant levels of contaminants in the offshore project area and so there is no potential for an AEoI due to re-mobilisation of contaminated sediments.

5.3.3.2.5 Maintain natural levels of turbidity

217. The effects of increased SSC have been discussed in Section 5.2.3.1.1 and in PEIR Chapter 8 Marine Geology and Physical Processes (Volume I). It can be concluded that increased SSC during construction activities will be indistinguishable from background levels and would be similar to that of a storm event. Therefore, habitats within the SPA will be tolerant of change in SSC and there will be no AEoI of this attribute of the supporting habitats.

5.3.3.3 Potential effects during decommissioning

218. A decision regarding the final decommissioning policy is yet to be decided as it is recognised that rules and legislation change over time in line with best industry practice. The decommissioning methodology and programme would need to be finalised nearer to the end of the lifetime of the Project to ensure it is in line with the most recent guidance, policy and legislation.

219. The scope of the decommissioning works would most likely involve removal of the accessible installed components. This is outlined in PEIR Chapter 5 Project Description (Volume I) and the detail would be agreed with the relevant authorities at the time of decommissioning. Offshore, this is likely to include removal of some or all of the export cables. Scour and cable protection would likely be left in situ.

220. During the decommissioning phase, there is potential for cable removal activities to cause effects that would be comparable to those identified for the construction phase (Section 5.3.3.1).

221. Effects associated with cable protection, if left in situ, would remain as assessed for the operational phase (Section 5.3.3.2).

222. The decommissioning effects will therefore be comparable to or less than the construction and operational phase. Therefore, an AEoI can be ruled out.

5.3.3.4 Effect of project alone

223. With no potential for an AEoI of the attributes discussed above, an AEoI of the supporting habitats of the SPA can therefore be ruled out. The effects on red-throated diver are assessed in Section 7.2.3.1.3.

5.3.3.5 In-combination effects

224. The in-combination assessment considers other developments (plans or projects) in planning, construction or operation where the predicted effects on the Outer Thames Estuary SPA supporting habitats may have the potential to interact with effects from the proposed construction, O&M or decommissioning of North Falls.

225. Plans and projects within the 50km search area have been identified are listed below in Table 5.13.

Table 5.13 Summary of plans and projects considered for the in-combination assessment in relation to the supporting habitats of the SPA

Plan or project	Status	Construction period	Closest distance to the North Falls offshore project area (km)	Confidence in data	Included in the in-combination assessment	Rationale
NeuConnect Interconnector	Pre-construction	2022-2028	0	High	Yes	The NeuConnect Interconnector bisects the North Falls offshore cable corridor and the SPA so there is potential for temporal overlap of cable installation activities.
BritNed Interconnector	Operational since 2009	N/A	0	High	No	The BritNed Interconnector passes through the SPA but has been operational since 2009. Therefore this is part of the baseline of the supporting habitat status.
Nautilus Interconnector	Pre-application	2025-2028	Cable route unknown	Low	Yes (Subject to available information)	The offshore study area for Nautilus intersects with the North Falls offshore project area, Therefore, there is potential for in-combination effects, subject to the final location and programme for the interconnector.
Sea Link	Pre-application	2026-2030	Cable route unknown	Low	Yes, for offshore construction effects only	The emerging preferred and alternative routes for Sea Link intersect with

Plan or project	Status	Construction period	Closest distance to the North Falls offshore project area (km)	Confidence in data	Included in the in-combination assessment	Rationale
					(Subject to available information)	the North Falls offshore cable corridor. Therefore, there is potential for in-combination effects, subject to the final location and programme for the interconnector.
Tarchon Energy Interconnector	Pre-planning	Unknown	Cable route unknown	N/A	Yes (Subject to available information)	Interconnector between UK and Germany with potential to be in proximity to the North Falls offshore project area.
GGOW	Operational since 2012	N/A	0	Medium	No	Both GGOW and GWF are operational and beyond the zone of influence for the supporting habitats of the SPA, therefore there is no potential in-combination effect.
GWF	Operational since 2018	N/A	0	Medium	No	
Five Estuaries OWF	In planning	Unknown	0	Medium	Yes	The Five Estuaries offshore cable corridor follows a similar route to the North Falls offshore cable corridor and has a similar construction programme.

Plan or project	Status	Construction period	Closest distance to the North Falls offshore project area (km)	Confidence in data	Included in the in-combination assessment	Rationale
East Anglia ONE North and East Anglia TWO OWFs	Consent granted	Construction planned mid 2020s	14.8	High	Yes	Export cable corridor for these projects overlaps the SPA.
Thanet OWF	Operational since 2010	N/A	24.4	Medium	No	
Gunfleet Sands OWF	Operational since 2010	N/A	10.3	Medium	No	Operational since 2013 and is therefore part of the existing conservation status of the SPA.
London Array OWF	Operational since 2013	N/A	15.5	Medium	No	
Outer OTE aggregate exploration and option are 528/2	Unknown	N/A	8.4	Low	Yes (Subject to available information)	There is potential for interaction between dredging and aggregate exploration on the SPA.
East Orford Ness aggregate exploration and option area 1809	Unknown	N/A	2	Low	No	Due to distance from the SPA (c. 7km for area 1809 and c.9.5km for area 524) there will be no AEoI of the site from temporal overlap of dredging / aggregate exploration and the Project.
Thames D aggregates production agreement area 524	Production agreement secured 2022	2022-2036	0	Low	No	
Southwold East aggregates production agreement area 430	Operational since 2012	N/A	27.3	Medium	No	Sites which were operational at the time of the North Falls characterisation surveys are a
North Inner Gabbard aggregate production area 498	Operational since 2015	N/A	1.7	Medium	No	

Plan or project	Status	Construction period	Closest distance to the North Falls offshore project area (km)	Confidence in data	Included in the in-combination assessment	Rationale
Shipwash aggregate production agreement area 507	Operational since 2016	N/A	0.2	Medium	No	component of the baseline environment.
North Falls East aggregate production agreement area 501	Operational since 2017	N/A	13.2	Medium	No	
Longsand aggregate production agreement area 508	Operational since 2014	N/A	5.8	Medium	Yes (Subject to available information)	There is potential for interaction between dredging and aggregate exploration on the SPA.
Longsand aggregate production agreement area 509	Operational since 2015	N/A	2.1	Medium	Yes (Subject to available information)	
Longsand aggregate production agreement area 510	Operational since 2015	N/A	3.5	Medium	Yes (Subject to available information)	

226. Relevant projects which have potential spatial and temporal overlap with the Outer Thames Estuary SPA and North Falls offshore export cable installation are the NeuConnect, Nautilus, Sea Link and Tarchon Interconnectors; the Five Estuaries export cables; the East Anglia ONE North and East Anglia TWO offshore cable corridor; and aggregate sites (528/2, 508, 509 and 510).

227. Scottish Power Renewables (SPR) (2020) assesses the affected area of each habitat type within the East Anglian ONE North and TWO offshore cable corridor. The area of disturbance of each habitat type within the 20m water depth which is potentially ecologically important to red-throated diver, ranges from 0.007% to 0.2% of the habitat available within the SPA.

228. It is assumed the effects of Five Estuaries would be similar to North Falls offshore export cable installation. Insufficient information is currently available regarding the effects of the interconnector projects.

229. With Five Estuaries, East Anglia ONE North and East Anglia TWO, effects would be less than 1% of each of the supporting habitats (as per Section 5.3.3.1). Locations of effect would be discrete and the effect would be temporary.

230. During operation, disturbance events would be episodic and spatially discrete. The permanent habitat loss from cable protection (assuming a worst case of all cable protection being within the SPA and maximum overlap with each habitat type) is small in absolute terms and relative to the total extent of each of the habitat types, even if multiple projects are considered.

231. In conclusion, it is considered that there would be no AEoI from in-combination effects.

6 Marine mammals (Annex II species)

6.1 Approach to assessment

232. For each European site screened into the Appropriate Assessment the following has been provided:

- A summary of the ecology of the marine mammal species relevant for each designated site assessment;
- An assessment of the potential effects during the construction, operation, maintenance and decommissioning phases of North Falls; and
- An assessment of the potential for in-combination effects for North Falls alongside other relevant developments and projects.

6.1.1 Consultation

233. The key elements of consultation to date have included scoping and the ongoing technical consultation via the marine mammal ETG. The feedback received has been considered in preparing this draft RIAA. Table 6.1 provides a summary of how the consultation responses received to date have influenced the approach that has been taken.

Table 6.1 Consultation Responses Relevant to Marine Mammal Sections of the RIAA

Consultee	Date/ Document	Comment	Applicant Responses
Planning Inspectorate	Scoping opinion - 26/08/2021	Para 244 Figure 2.1 Designated sites and study area. The aspect chapter does not reference any designated sites other than the Southern North Sea SAC (designated for harbour porpoise), despite several other European designated sites and Marine Protected Areas being present within the vicinity of the Proposed Development (as shown in Figure 2.1). Therefore, the extent to which these offshore designated sites and their qualifying / protected features have been considered within the marine mammal assessment is not clear. No reference is made to a defined study area and / or methodology that will be used to establish the baseline and assess impacts, nor is any criteria presented to identify how significance of effect will be determined. The ES should be clear on how the assessment has been undertaken, taking into relevant guidance and using an aspect specific methodology where this is relevant.	Sites screened into the assessment are listed in Table 4.1 and Section 4.3. The study area and methodology to establish features / sites to be considered are listed above in paragraph 232.
Planning Inspectorate	Scoping opinion - 26/08/2021	Section 2.7.3.1 Para 390 Approach to assessment – underwater noise modelling. The Scoping Report states that underwater noise modelling will be undertaken to inform the marine mammal assessment; however, limited information is provided regarding the proposed assessment methodology. It's unclear, for example, which receptors underwater noise modelling will be applied to / undertaken for. The Environmental Statement (ES) should fully describe the methodology applied, including Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) and disturbance ranges used, as well as the potential for the disturbance impact footprints to overlap with the boundary of offshore designated sites, including the Southern North Sea SAC. If noise modelling indicates an overlap of the disturbance footprint with an offshore designated site, the area and duration of such disturbance will need to be assessed against the conservation objectives of the designated site. The Inspectorate understands that the number, type and size of UXO devices is not known. However, the ES should assess the likely impacts from UXO (including the potential for auditory injury	An assessment of potential disturbance effects to the Southern North Sea SAC has been provided within Section 6.2 of this draft RIAA. Given that impact from UXO clearance will be from North Falls as well as from other projects, UXO clearance has been assessed within the in-combination assessment (Sections 6.2.3.4, 6.3.3.4, 6.4.3.4) It is not envisaged that UXO clearance would be required after the construction phase. The project layout will be determined and potential UXO either avoided or cleared at that stage. O&M activities would be localised around the infrastructure installed and therefore any UXO presence would have already been identified and cleared or avoided

Consultee	Date/ Document	Comment	Applicant Responses
		from underwater noise from UXO clearance, as well as other construction activities) and explain the assumptions applied to the assessment as necessary. The ES should also clarify whether UXO are envisaged during the operations and maintenance phased of the Proposed Development.	
Natural England	HRA Screening 29/10/21	Natural England does not consider that “changes to prey availability and any disturbance to foraging at sea” can be screened out during the decommissioning phase. There is currently little information on the activities that will be taken as part of decommissioning and no information provided to demonstrate that this will not affect the prey and/or foraging of marine mammals.	Decommissioning effects are included for each European site with reference to the construction effects (see Sections 6.2.3.3, 6.3.3.3 and 6.4.3.3)
Natural England	HRA Screening 29/10/21	As this is a standalone report, we advise that a summary of the presence of Annex II marine mammal species in the project area would be beneficial, to demonstrate why certain species have been considered and not others.	This has been added to the HRA Screening report, provided in Appendix 1
Natural England	HRA Screening 29/10/21	We advise that the report should include information to demonstrate the appropriateness of the MUs screened in for seals e.g., maps of telemetry showing connectivity to the MUs outside of those that the project is located within.	Information on the populations and MU used is provided in the Site Overview section for each European site (Sections 6.2.1, 6.3.1, 6.4.1,and relevant subsections of Section 6.5)
Natural England	HRA Screening 29/10/21	We advise that the report should include a figure showing the extent of the MUs being used for screening. In addition, references should be added to demonstrate where the MUs have come from	
Natural England	HRA Screening 29/10/21	We advise that the Wadden Sea population is not included in the reference population. Although we acknowledge the connectivity between the populations, the Wadden Sea population should be considered as part of the transboundary assessment, rather than in the core assessment.	The Wadden Sea population has been removed from the assessments and Carter (2022) used to establish connectivity to SACs and the populations used for each assessment.
Natural England	HRA Screening 29/10/21	We note that, here, the report states that the extent of the reference population for seals are certain MUs. However, this does not appear to be the same as the screening extent in Table 6.2, which is referred to as OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) Region II. Greater clarity is needed	Information on the populations and MU used is provided in the Site Overview section for each European site (Sections 6.2.1, 6.3.1, 6.4.1,and relevant subsections of Section 6.5)
Natural England	HRA Screening 29/10/21	Given that the report is proposing to include the north-east England MU in their reference population for grey seals, we question why you not screened in	The Carter et al. (2022) report shows no presence of grey seal associated with the

Consultee	Date/ Document	Comment	Applicant Responses
		Berwickshire and North Northumberland Coast (B&NNC) SAC for grey seal. By including the north-east MU in the reference population, the report is acknowledging that there is connectivity between the project and the MU population, in that seals in the project area could originate from either the south-east or north-east MU as these two populations act as a single large population. However, grey seals in the north-east MU are almost certainly connected to the B&NNC SAC as it is the only SAC in the MU and supports the vast majority of August hauled-out seals (Special Committee on Seals (SCOS), 2020). Furthermore, we consider that there is potential for connectivity between the B&NNC SAC and the project site based on Vincent et al. (2017) and more broadly the known wide-ranging foraging habitats of grey seal in the North Sea. We therefore advise that the grey feature of the B&NNC SAC is screened in to the HRA.	B&NNC SAC within the North Falls project areas (Figure 7.3, Appendix 1), with the closest presence of any grey seal from that SAC being 28.7km from the closest point of North Falls, which is further than any potential effect range assessed.
Natural England	HRA Screening 29/10/21	We advise that the Humber Estuary is also a Ramsar site and, as per UK policy, should be assessed in the same way as the SAC.	Noted, this is covered in sections 6.3.1 and 6.3.2.
Natural England	HRA Screening 29/10/21	The report states that the typical foraging ranges for grey seal is 100km, and for harbour seal 80km.	Telemetry data will be reviewed to determine potential for connectivity between offshore project area and designated sites.
Natural England	HRA Screening 29/10/21	Although we acknowledge that non-UK sites are outside of Natural England's remit, we note that there are several non-UK sites designated for harbour porpoise that are within the North Sea MU but have been screened out.	Non UK sites are covered in Section 6.5.
Natural England	HRA Screening Update 2/12/22	Natural England agrees with the summary of potential effects, and we note that the Applicant considered our previous advice to screen in "changes to prey availability and any disturbance to foraging at sea" during decommissioning.	Noted.
Natural England	HRA Screening Update 2/12/22	In-combination assessment should take in to consideration geophysical surveys and any potential oil and gas (O&G) surveys.	Geophysical surveys have been assessed within the in-combination assessment (Sections 6.2.3.4, 6.3.3.4, 6.4.3.4).
Natural England	HRA Screening Update 2/12/22	The foraging distance of grey seals should be revised following new information from Carter et al (2022) which suggest that grey seal undertake foraging trips up to 448km. This	Carter et al (2022) has been used to update the assessments (see sections 6.3 and 6.4).

Consultee	Date/ Document	Comment	Applicant Responses
		information should also be used to revise the connectivity between the project area and protected sites.	
Natural England	HRA Screening Update 2/12/22	More up to date maps are available from Carter et al 2020 should be used to depict global position system (GPS) tracking data for seals. We consider the approach of using telemetry data to determine connectivity is favourable compared to using a single foraging range, which is oversimplistic and does not reflect the variation in movements intra- and inter-sites. Telemetry data can also be used to determine connectivity to transboundary sites.	
Natural England	HRA Screening Update 2/12/22	We note the use of Greater North Sea OSPAR region II as a MUfor grey seals. This region can be useful for screening in transboundary sites. We, however, advise the use of OSPAR AUs as presented in SCOS reports (please see SCOS 2021, Figure 4 and Figure 8). All AUs which have connectivity to the project should be considered as well as telemetry data and known foraging ranges (See Best Practice Phase III document). Thus, for grey seals, South East (SE) England and North East (NE) England AUs (or Seal MU as per SCOS 2021) should be considered.	This has been revised in the HRA Screening report, provided in Appendix 1.
Natural England	HRA Screening Update 2/12/22	The foraging distance of harbour seals should be revised following new information from Carter et al 2022 which suggest that they undertake foraging trips up to 273km. This information should also be used to revise the connectivity between the project area and protected sites.	Carter et al (2022) has been used to update the assessments (see Section 6.4).
Natural England	HRA Screening Update 2/12/22	We note the use of Greater North Sea OSPAR region II as a MU for harbour seal. This region can be useful for screening in transboundary sites. We, however, advise the use of OSPAR AU as presented in SCOS reports (please see SCOS 2021, Figure 4 and Figure 8). All AUs which have connectivity to the project should be considered as well as telemetry data and known foraging ranges (See Best Practice Phase III document). Thus, we advise the use of Seal MUs from SCO 2021 whereby SE England Seal MU for harbour seals should be considered.	This has been revised in the HRA Screening report, provided in Appendix 1.
Natural England	HRA Screening Update 2/12/22	B&NNC SAC for grey seal should be added to the list of screened in sites as per our previous advice due to the connectivity between the B&NNC SAC and the project site based on Vincent et al. (2017) and more broadly the known	The Carter et al. (2022) report shows no presence of grey seal associated with the Berwickshire and North Northumberland Coast

Consultee	Date/ Document	Comment	Applicant Responses
		wide-ranging foraging habitat of grey seal in the North Sea.	SAC within the North Falls project areas (Figure 7.3, Appendix 1), with the closest presence of any grey seal from that SAC being 28.7km from the closest point of North Falls, which is further than any potential effect range assessed. In addition, the north-east England MU is no longer included within the assessed population of grey seal
Natural England	HRA Screening Update 2/12/22	Natural England advises North Falls to revise this table [Table 7.2] in the light of new information on foraging distances of seals as per Carter et al 2022. B&NNC SAC for grey seal should be scoped in. We also suggest putting the UK sites at the top of the table, not at the end.	
The Wildlife Trusts (TWT)	HRA Screening 29/10/21	The HRA should consider “changes to prey availability and associated habitats, and any disturbance to foraging at sea” to marine mammal features. TWT are not comfortable with “barrier effects due to the physical presence of offshore infrastructure” being screened out at this stage.	Changes to prey availability are assessed for all European sites for construction, operation and decommissioning. Physical barrier effects are not included. This is agreed with Natural England
The Wildlife Trusts (TWT)	HRA Screening 29/10/21	The meaning of this sentence needs to be made clearer in order to ensure consistency with the other receptors. Is this a list of marine mammal sites where LSE could not be ruled out?	This has been amended in the HRA Screening report. In addition, a summary of the sites screened-in, where LSE could not be ruled out is provided in Section 4.3

6.1.2 Worst case scenario

234. The final design of North Falls will be confirmed through detailed engineering design studies that will be undertaken post-consent. In order to provide a precautionary but robust impact assessment at this stage of the development process, realistic worst case scenarios have been defined in terms of the potential effects that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set out in Planning Inspectorate Advice Note Nine (2018). The Rochdale Envelope for a project outlines the realistic worst case scenario for each individual impact, so that it can be safely assumed that all other scenarios within the design envelope will have less impact.

235. The realistic worst case scenarios for the likely significant effects scoped into the EIA for the marine mammal assessment are summarised in Table 6.2.

236. A range of WTG sizes are included in the design envelope, which take into account currently available models and predicted technology developments. Table 6.2 outlines the parameters of relevance to marine mammals associated

with the range of WTGs, from the greatest number of smallest WTG to the fewest, largest WTG within the envelope[3].

[3] Further information on the scaling up from existing noise data is provided in PEIR Volume III, Appendix 12.2.

Table 6.2 Realistic worst case scenarios for the likely significant effects scoped in for the marine mammal assessments

Potential impact	Parameter	Notes
Construction		
Impact 1: Underwater noise during piling, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Spatial worst case scenario: • 72 WTGs on monopile foundations; • Two OSP on monopile foundations; • Maximum pile diameter for WTG and OSP monopiles: 17m • 6,000 kJ hammer energy, 7.5 hours piling duration per monopile including a 10 minute soft start at 15% hammer energy and 120 minute (2 hour) ramp up to full energy (where required); • Maximum number of monopiles to be installed per 24 hour period: two • Total WTG active piling duration: 540 hours (equivalent to 22.5 days); • Total OSP active piling duration: 15 hours (less than one day); • Duration of foundation installation: 12 months • Simultaneous piling: only two piles will be piled simultaneously within the North Falls array areas. Temporal worst case scenario: • 72 WTGs on pin-piled jacket foundations, four piles per jacket (288 total); • Two OSPs with six piles each (12 total piles); • Maximum pile diameter for WTG and OSP pin piles: 3.5m • 3,000 kJ hammer energy, 4.5 hours piling duration including a 10 minute soft start and 80 minute ramp up to full energy (where required); • Maximum number of pin piles to be installed per 24 hour period: four; • Total WTG active piling duration: 1,296 hours (equivalent to 54 days); • Total OSP active piling duration: 54 hours (equivalent to 2.25 days); • Duration of foundation installation: 12 months • Simultaneous piling: only two piles will be piled simultaneously within the North Falls array areas. • Additional disturbance from Acoustic Deterrent Devices (ADD): • Indicative activation time of 10 minutes	The spatial worst case scenario is based on the largest hammer energy which is required for monopile foundations. The temporal worst case scenario is based on the greatest number of piles which is the pin-piled jacket foundations. Full hammer energy is unlikely to be required on all piles but is assessed for all piles as a worst case scenario. Drive-drill-drive is an option for installation, however, 100% pile driving is the worst case and has been assessed. Alternative foundation types (including suction bucket monopiles, and gravity based for both monopiles and pin piles) are an option, but do not represent the worst case for underwater noise. Activation of ADD is indicative only and the details will be confirmed during the post-consent phase, through the finalisation of the Marine Mammal Mitigation Protocol (MMMP).
Impact 2: Underwater noise during other construction activities, including:	UXO devices that could be present within the North Falls offshore project area has been estimated as 698 kg. 15 clearance operations are estimated.	Appendix 12.2 (Volume III) provides underwater noise modelling for 698kg alongside a range of smaller devices, these are 25, 55, 120, 240 and 525 kg.

Potential impact	Parameter	Notes
• Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Seabed clearance methods: Pre-lay grapnel run, boulder clearance, sand wave levelling (pre-sweeping), dredging	Appendix 12.2 (Volume III) provides underwater noise modelling for suction dredging to represent the worst case scenario of these activities.
	Cable installation methods: It is anticipated that the offshore cables will be installed via either ploughing, jetting, trenching, or a combination of these techniques. Surface laid cable protection could be required in areas where cables cannot be buried (e.g. at cable crossings and hard ground conditions. Array cables total length: 228km Offshore export cable total length 250.8km (based on 4 cables) Indicative duration of offshore construction: approximately three years (including commissioning)	Appendix 12.2 (Volume III) provides underwater noise modelling for cable laying, trenching and rock placement to represent the worst case scenario for these activities.
Impact 3: Underwater noise due to construction vessels, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Vessel movements: • Maximum Indicative peak number of construction vessels on site at any one time: up to 35 vessels • Construction vessel trips to port (movements): 3,090 over three year offshore construction period (average of 1,030 movements per year; 3 movements per day) • Construction port: currently unknown.	The maximum numbers of vessels and associated vessel movements represents the maximum potential for disturbance. Appendix 12.2 (Volume III) provides underwater noise modelling for noise from large and medium sized vessels
Impact 4: Barrier effects due to underwater noise during construction	Maximum impact range from all three underwater noise assessments (worst case parameters described above).	The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst case barrier impact.
Impact 5: Collision risk due to construction vessels	Vessel movements: • Maximum Indicative peak number of construction vessels on site at any one time: up to 35 vessels • Construction vessel trips to port (movements): 3,090 over three year offshore construction period (average of 1,030 movements per year; 3 movements per day)	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk.

Potential impact	Parameter	Notes
	Construction port: currently unknown.	
Impact 6: Disturbance at seal haul-out sites	Vessel movements: • Maximum Indicative peak number of construction vessels on site at any one time: up to 35 vessels • Construction vessel trips to port (movements): 3,090 over three year offshore construction period (average of 1,030 movements per year; 3 movements per day) Location of works: • Minimum distance of array areas to coastline: 22.5km • Landfall search area: between Clacton-on-Sea and Frinton-on-Sea, Essex. • Construction port: currently unknown Indicative duration of offshore construction: approximately three years (including commissioning)	Number of vessel movements and proximity to seal haul out sites defines the worst case scenario.
Impact 7: Changes to water quality	• Suspended sediments arising from: • Seabed preparation for foundation installation = 1.4Mm^3 • Offshore cable installation = 27.6Mm^3 • Offshore export cable installation = 30.4Mm^3	The worst case scenario for marine mammals is based on the conclusions of the assessments presented in Chapter 9 Marine Water and Sediment Quality (Volume I in PEIR).
Impact 8: Changes to prey resources	Prey impacts from temporary habitat loss/ disturbance: Total seabed disturbance within the offshore project area = 13.3km2 (6.98km2 in the array areas and 6.32km2 in the offshore cable corridor)	The worst case scenario for maximum area of temporary habitat loss / disturbance of seabed from offshore cable installation, seabed preparation, jack-up vessels and anchoring). See Chapters 10 and 11 in the North Falls PEIR (Volume I) for further detail. Worst case scenario for marine mammals is based on the conclusions of the assessments presented in Chapter 10 Benthic Ecology and Chapter 11 Fish and Shellfish Ecology (PEIR Volume I).
	Prey impacts from underwater noise parameters as outlined for Impacts 1 to 3, above and Appendix 12.2 Underwater Noise Modelling Report (Volume III of PEIR)	
	Prey impacts resulting from changes to water quality as described for Impact 7, above	
Operation		

Potential impact	Parameter	Notes
Impact 1: Underwater noise from operational wind turbines, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Indicative operational life of North Falls: 30 years Number of WTGs: • 72 x smallest WTGs (rotor diameter 164-250m), or • 40 x largest WTGs (rotor diameter 200-337m) Minimum turbine spacing: • Smallest WTGs = 0.82km, or • Largest WTGs = 1.685km.	Worst case assessment is based on the underwater noise modelling results presented Appendix 12.2 Underwater Noise Modelling Report (Volume III of PEIR).
Impact 2: Underwater noise from O&M activities, including: • Permanent auditory injury; • Temporary auditory injury; and • Disturbance.	Unplanned repairs and reburial of cables may be required during O&M, the following estimates are included: • Reburial of c. 5km of array/interconnector cable is estimated over the life of the Project • Reburial of c. 5km of offshore export cable is estimated over the life of the Project • Five array/interconnector cable repairs are estimated over the Project life. • Four offshore export cable repairs are estimated over the Project life. Anchored vessels placed during the no. of cable repairs include above Maintenance of offshore infrastructure would be required during O&M. An estimated 180 major component replacement activities may be required per year, using jack up vessels and/or anchoring	Underwater noise modelling for other activities presented Appendix 12.2 Underwater Noise Modelling Report (Volume III of PEIR).
Impact 3: Underwater noise due to O&M vessels	Indicative peak number of vessels on site at any one time: 22 • Two jack-up vessels • Two Service Operation Vessels (SOVs) • Six small O&M vessels (e.g. crew transfer vessels (CTVs) • Two lift vessels • Two cable maintenance vessels • Eight auxiliary vessels (e.g. survey vessels, diver platform vessels, tugs, cargo vessels, scour replacement vessels)	Worst case is based on the maximum number of vessel movements.
	Indicative O&M vessel movements per year: 1,460 round trips of small vessels, and 127 round trips of large vessels (1587 in total): • Seven round trips per year of jack-up vessels	

Potential impact	Parameter	Notes
	• 52 SOV round trips per year • 1,460 small O&M vessel round trips per year • Seven round trips per year of lift vessels • One cable maintenance vessel round trip per year • 60 round trips per year of auxiliary vessels, dependent on size of vessel	
Impact 4: Barrier effects due to underwater noise during operation	Maximum impact range from O&M phase underwater noise impacts 1 to 3 (as above).	The maximum spatial area of potential impact, and duration of impacts, are considered to cause the worst case barrier effect.
Impact 5: Increased collision risk due to O&M vessels	Indicative O&M vessel movements per year: 1,460 round trips of small vessels, and 127 round trips of large vessels (1,587 in total).	The maximum numbers of vessels and associated vessel movements represents the maximum potential for collision risk.
Impact 6: Disturbance at seal haul-out sites	Vessel movements: • Indicative O&M vessel movements per year: 1,460 round trips of small vessels, and 127 round trips of large vessels (1587 in total). • • Location of works: • Minimum distance of array areas to coastline: 22.5km • O&M base location: currently unknown.	Operation and maintenance activities could happen at any time of year.
Impact 7: Changes to water quality	Suspended sediments arising from: • Reburial of c. 5km of array/interconnector cable is estimated over the life of the Project • Reburial of c. 5km of offshore export cable is estimated over the life of the Project • Five array/interconnector cable repairs are estimated over the Project life. • Four offshore export cable repairs are estimated over the Project life.	The worst case scenario for marine mammals is based on the conclusions of the assessments presented in Chapter 9 Marine Water and Sediment Quality.
Impact 8: Changes to prey resources	Prey impacts from habitat loss within the offshore project area = 6.84km^2 (6.69km^2 in the array areas and 0.15km^2 in the offshore cable corridor) Prey impacts from underwater noise parameters as outlined for Impacts 1 to 3, above and Appendix 12.2 Underwater Noise Modelling Report (Volume III in PEIR).	The worst case scenario for maximum area of temporary habitat loss / disturbance of seabed from offshore cable installation, seabed preparation, jack-up vessels and anchoring).

Potential impact	Parameter	Notes
	Prey impacts resulting from changes to water quality as described for Impact 7, above	See Chapters 10 and 11 for further detail (PEIR Volume I). Worst case scenario for marine mammals is based on the conclusions of the assessments presented in Chapter 10 Benthic Ecology and Chapter 11 Fish and Shellfish Ecology (PEIR Volume I).
Decommissioning		

Impact 1: Underwater noise from decommissioning activities
 	
Impact 2 & 4: Underwater noise and increased collision risk due to decommissioning vessels
 	
Impact 3: Barrier effects from underwater noise during decommissioning
 	
Impact 5: Disturbance at seal haul-out sites
 	
Impact 6: Changes to water quality
 	
Impact 7: Changes to prey resources
	Foundations
	Cutting of piles below the seabed surface:
	• 300 pin-piles of 3.5m diameter
	    ○ 72 wind turbines x 4 piles
	    ○ 2 OSPs x 6 piles
	Or
	• 74 monopiles of 17m diameter (72 wind turbines + 2 OSPs)
	
	Offshore xport cables
	Up to 250.8km of offshore export cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)
	
	Array cables
	Up to 228km of array/interconnector cable (removal to be determined in consultation with key stakeholders as part of the decommissioning plan)
		No decision has yet been made regarding the final decommissioning arrangements for the offshore project infrastructure. It is also recognised that legislation and industry best practice change over time. However, the following infrastructure is likely to be removed, reused or recycled where practicable:
		• Turbines including monopile, steel jacket and GBS foundations;
		• OSPs including topsides and steel jacket foundations; and
		• Offshore cables may be removed or left in situ depending on available information at the time of decommissioning.
		The following infrastructure is likely to be decommissioned in situ depending on available information at the time of decommissioning, however where it represents the worst case scenario (e.g. for disturbance, removal is assessed):
		• Scour protection;
		• Offshore cables may be removed or left in situ; and
		• Crossings and cable protection.
		The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of

Potential impact	Parameter	Notes
		decommissioning and will be agreed with the regulator. Decommissioning arrangements will be detailed in a Decommissioning Plan, which will be prepared in accordance with the Energy Act 2004.

6.1.3 Embedded mitigation

237. This section outlines the embedded mitigation relevant to the marine mammal assessments, which has been incorporated into the design of North Falls (Table 6.3).

Table 6.3 Embedded mitigation

Parameter	Mitigation measures embedded into North Falls design
Underwater Noise	
Soft-start and ramp-up for piling activities	Each piling event would commence with a soft-start at a lower hammer energy followed, by a gradual ramp-up for at least 20 minutes to the maximum hammer energy required (the maximum hammer energy is only likely to be required at a few of the piling installation locations.
Vessel collision risk	
Best practice to reduce vessel collision risk	Vessel movements, where possible, will follow set vessel routes and hence areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. All vessel movements will be kept to the minimum number that is required to reduce any potential collision risk. Additionally, vessel operators will use best practice to reduce any risk of collisions with marine mammals.
Water Quality	
Pollution prevention	The Applicant is committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction, O&M, and decommissioning activities. An outline Project Environmental Management Plan (PEMP) will be developed and submitted alongside the DCO application to set out the details of the measures that will be taken in relation to accidental pollution events. The final PEMP would be agreed with the MMO prior to construction.

6.1.4 Additional mitigation

238. Mitigation will be required for the following activities, and will use the relevant JNCC guidelines as standard (the relevant guidelines are noted below);

- UXO clearance
- Following the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010a)
- Piling
- Following the Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010b)

239. While the JNCC guidelines will be used as a standard, they may be adapted to ensure that the predicted instantaneous and cumulative PTS ranges are mitigated against, for all marine mammal species. It is expected that ADDs will be used as part of the mitigation for both UXO clearance and piling. Mitigation and monitoring protocols will be developed for each of the above listed activities.

240. Mitigation and monitoring will be secured through the following management plans (Table 6.4). An outline MMMP and Southern North Sea (SNS) SAC Site Integrity Plan (SIP) will be submitted with the DCO application.

Table 6.4 Additional mitigation

Parameter	Additional mitigation measures
MMMP for piling activities	
MMMP for Piling Activities	The MMMP for piling will be developed in the pre-construction period and based upon best available information, methodologies, industry best practice, latest scientific understanding, current guidance and detailed project design. The MMMP for piling will be developed in consultation with the relevant SNCBs and the MMO, detailing the proposed mitigation to reduce the risk of any physical or permanent auditory injury (PTS) to marine mammals during all piling operations.
MMMP for UXO Clearance	
MMMP for UXO	A detailed MMMP will be prepared for UXO clearance during the pre-construction phase. The MMMP for UXO clearance will ensure there is adequate mitigation to minimise the risk of any physical or permanent auditory injury to marine mammals as a result of UXO clearance. The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information on the UXO clearance which could be required and the most suitable mitigation, based upon best available information and methodologies at that time, in consultation with the MMO and relevant SNCBs. The MMMP for UXO clearance will include details of all the required mitigation to minimise the potential risk of physical and auditory injury (PTS) as a result of underwater noise during UXO clearance, for example, this would consider the options, suitability and effectiveness of mitigation such as, but not limited to: • Low-order disposal technique, such as deflagration; • The use of bubble curtains (taking into consideration the environmental limitations); • All detonations to take place in daylight and, when practicable, in favourable conditions with good visibility (sea state 3 or less); • Establishment of a monitoring area with minimum of 1km radius. • The observation of the monitoring area will be by dedicated and trained marine mammal observers during daylight hours and suitable visibility; • The activation of ADDs; • The controlled explosions of the UXO will be undertaken by specialist contractors, using the minimum amount of explosive required in order to achieve safe disposal of the UXO; and • Other UXO clearance techniques, such as the use of scare charge; multiple detonations, if UXO are located in close proximity; avoidance of UXO; or relocation of UXO.
Site Integrity Plan	
Southern North Sea SAC Site Integrity Plan	In addition to the MMMPs for piling and UXO clearance, a Southern North Sea SAC SIP will be developed. The SIP will set out the approach to deliver any project mitigation or management measures to reduce the potential for any significant disturbance of harbour porpoise in relation to the Southern North Sea SAC conservation objectives. The SIP will be an adaptive management tool, which can be used to ensure that the most adequate, effective and appropriate measures, if required, are put in place to reduce the significant disturbance of harbour porpoise in the Southern North Sea SAC. The SIP will be developed in the pre-construction period and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO.

241. A summary report will be provided following all activities as outlined above, to provide detail on the activities and mitigation undertaken. The summary reports

will also provide detail on any marine mammal presence during each of the relevant activities.

6.1.5 Definition of significance

242. The potential effects have been assessed for each of the designated sites for marine mammals for construction, operation, maintenance and decommissioning at North Falls.

243. Assessments of the potential for adverse effects, at the population level, have been based on the JNCC et al. (2010) draft guidance for effects on EPS, and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) agreement.

244. The JNCC et al. (2010) draft guidance provides some indication on how many animals may be removed from a population without causing detrimental effects to the population at FCS. The JNCC et al. (2010) draft guidance also provides limited consideration of temporary effects, with guidance reflecting consideration of permanent displacement.

245. JNCC et al. (2010) draft guidance considered 4% as the maximum potential growth rate in harbour porpoise, and the 'default' rate for cetaceans. Therefore, beyond natural mortality, up to 4% of the population could theoretically be permanently removed before population growth could be halted. In assigning 5% to a temporary effect, consideration is given to uncertainty of the individual consequences of temporary disturbance.

246. Permanent effects with a greater than 1% of the reference population being affected within a single year are considered to result in a significant effect. This is based on ASCOBANS and Defra advice (Defra, 2003; ASCOBANS, 2015) relating to impacts from fisheries by-catch (i.e. a permanent effect) on harbour porpoise. A threshold of 1.7% of the relevant harbour porpoise population above which a population decline is inevitable has been agreed with Parties to ASCOBANS, with an intermediate precautionary objective of reducing the impact to less than 1% of the population (Defra, 2003; ASCOBANS, 2015).

247. As a precautionary approach, and as there is no current guidance on what determines a significant temporary or permanent effect, the above information on the potential for population level effects has been used to inform the approach to defining potential for adverse effect for harbour porpoise, grey seal and harbour seal populations. The approach to define the potential for adverse effect on the integrity of the site, based on the potential effect to the overall populations, is therefore as follows;

- For temporary effects, there would be potential for an adverse effect on the integrity of the site, if there is an effect to 5% or more of the population; and
- For permanent effects, there would be potential for an adverse effect on the integrity of the site, if there is an effect to 1% of more of the population.
- The exception to this approach is the use of the Effective Deterrent Range (EDR) spatial approach for disturbance impacts upon harbour porpoise within the SNS SAC (see section 6.2.3.1.1), following the guidelines provided in JNCC *et al*. (2021).

6.2 Southern North Sea SAC

6.2.1 Site overview

248. The SNS SAC has been recognised as an area with persistent high densities of harbour porpoise (JNCC, 2017a; JNCC and Natural England, 2019) and is the largest designated site for harbour porpoise in UK and European waters at the time of designation.

249. The SNS SAC covers an area of 36,951km^2, with both winter and summer habitats of importance to harbour porpoise (JNCC, 2017a). Approximately 27,028km^2 of the site is important in the summer period (183 days from April to September inclusive) and 12,696km^2 of the site is important in the winter period (182 days from October to March inclusive) (JNCC et al., 2020). The majority of the site is less than 40m in depth, reaching up to 75m in the northern most areas.

250. The North Falls array areas are within winter area of the SNS SAC.

6.2.1.1 Qualifying Feature

6.2.1.1.1 Harbour porpoise

251. Within the southern North Sea area, harbour porpoise is the most common marine mammal species (Hammond et al., 2021). Heinänen and Skov (2015) identified that within the North Sea, water depth and hydrodynamic variables are the most important factors in harbour porpoise densities in species areas, in both winter and summer seasons. The seabed sediments also play an important role in determining areas of high harbour porpoise density, as well as the number of vessels present in the area.

252. Distribution and abundance maps have been developed by Waggitt et al. (2019) for harbour porpoise and show a clear pattern of high density in the southern North Sea, and the coasts of south-east England, for both January and July (Waggitt et al., 2019). Examination of this data, including all 10km grids that overlap with North Falls, including offshore cable corridor areas, indicates an average annual density estimate of:

- 0.382 individuals per km^2 for the North Falls array areas; and
- 0.389 individuals per km^2 for the North Falls export and interconnector cable corridors.

253. The North Falls offshore sites are in the SCANS-III (Small Cetaceans in the European Atlantic and North Sea) survey block L (Hammond et al., 2021) where:

- Abundance estimate = 19,064 harbour porpoise (95% Confidence Interval (CI) = 6,933 - 35,703); and
- Density estimate = 0.607 harbour porpoise/km^2 (Coefficient of Variation (CV) = 0.383).

254. Data from the North Falls site specific surveys have also been used to generate abundance and density estimates for the sites with a 4km buffer (for further details see PEIR Appendix 12.1 Marine Mammal Baseline (Volume III). The average of the winter months, summer months, and annual density has then been calculated based on the maximum calculated for each month. Table 6.5

shows the densities for harbour porpoise, based on all individuals that have the potential to be harbour porpoise.

Table 6.5 Maximum harbour porpoise summer, winter and annual density estimates for North Falls

Season	Maximum density estimate (corrected) for whole survey area (animals/km2)
Average winter	2.822
Average summer	1.515
Average annual	2.168

255. The site-specific surveys indicate a seasonal pattern in the abundance of harbour porpoise, with higher numbers present in the summer months. There is no evident pattern of harbour porpoise distribution within the survey area, with no indication of a particular area of importance.

256. It is not currently known at what time of year any activities associated with North Falls will take place, and therefore, as a precautionary approach, the worst case average winter density estimate of harbour porpoise from the site specific surveys (2.8 harbour porpoise/km^2) have been used in the impact assessments.

257. The Inter-Agency Marine Mammal Working Group (IAMMWG, 2022) define three MUs for harbour porpoise. The North Falls offshore sites are located in the North Sea MU.

258. The IAMMWG estimate of harbour porpoise abundance in the North Sea (NS) MU is 346,601 (CV = 0.09; 95% CI = 289,498 – 419,967) (IAMMWG, 2022). This is the reference population for harbour porpoise used in the assessments.

259. The SNS SAC Site Selection Report (JNCC, 2017a) identifies that the SNS SAC site supports approximately 18,500 individuals (95% CI = 11,864 - 28,889) for at least part of the year (JNCC, 2017a). However, JNCC and Natural England (2019) states that because this estimate is from a one-month survey in a single year (the SCANS-II survey in July 2005) it cannot be considered as an estimated population for the site. It is therefore not appropriate to use site population estimates in any assessments of effects of plans or projects on the site (i.e. HRA), as they need to take into consideration population estimates at the MU level, to account for daily and seasonal movements of the animals (JNCC and Natural England, 2019).

6.2.2 Conservation objectives

260. The Conservation Objectives for the SNS SAC are designed to help ensure that the obligations of the Habitats Directive can be met. Article 6(2) of the Habitats Directive requires that there should be no deterioration or significant disturbance of the qualifying species or to the habitats upon which they rely.

261. The Conservation Objectives (JNCC and Natural England, 2019) for the SNS SAC are:

262. “To ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining FCS for Harbour Porpoise in UK waters.

263. In the context of natural change, this will be achieved by ensuring that:

- Harbour porpoise is a viable component of the site;
- There is no significant disturbance of the species; and
- The condition of supporting habitats and processes, and the availability of prey is maintained".

264. These Conservation Objectives are:

265. "a set of specified objectives that must be met to ensure that the site contributes in the best possible way to achieving FCS of the designated site feature(s) at the national and biogeographic level" (JNCC and Natural England, 2019)".

6.2.2.1 Conservation Objective 1: The Species is a Viable Component of the Site

266. This Conservation Objective is designed to minimise the risk of injury and killing or other factors that could restrict the survivability and reproductive potential of harbour porpoise using the SAC. Specifically, this objective is primarily concerned with operations that would result in unacceptable levels of those impacts on harbour porpoise using the SAC. Unacceptable levels can be defined as those having an impact on the FCS of the population of the species in their natural range.

267. Harbour porpoise are considered to be a viable component of the SAC if they are able to live successfully within it. The SNS SAC has been selected primarily based on the long term, relatively higher densities of porpoise in contrast to other areas of the North Sea. The implication is that the SAC provides relatively good foraging habitat and may also be used for breeding and calving. However, because the number of harbour porpoise using the site naturally varies there is no exact value for the number of animals expected within the site (JNCC and Natural England, 2019).

268. The Conservation Objectives (JNCC and Natural England, 2019) state that, with regard to assessing impacts, 'the reference population for assessments against this objective is the MU population in which the SAC is situated'.

269. Harbour porpoise are listed as European Protected Species (EPS) under Annex IV of the Habitats Directive, and are therefore protected from the deliberate killing (or injury), capture and disturbance throughout their range. Under the Habitats Regulations, it is an offence if harbour porpoise are deliberately disturbed in such a way as to:

- Impair their ability to survive, to breed or reproduce, or to rear or nurture their young; or
- To affect significantly the local distribution or abundance of that species.

270. The term deliberate is defined as any action that is shown to be "by a person who knows, in the light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against a species, but intends this offence or, if not, consciously accepts the foreseeable results of his action".

271. In addition, Article 12(4) of the Habitats Directive is concerned with incidental capture and killing. It states that Member States "shall establish a system to monitor the incidental capture and killing of the species listed on Annex IV (all

cetaceans). In light of the information gathered, Member States shall take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned".

6.2.2.2 Conservation Objective 2: There is no significant disturbance of the species

272. The disturbance of harbour porpoise typically, but not exclusively, originates from operations that cause underwater noise, including activities such as seismic surveys, pile driving and sonar.

273. Disturbance is considered to be significant if it leads to the exclusion of harbour porpoise from a significant portion of the site for a significant period of time. The current SNCBs guidance for the assessment of significant noise disturbance on harbour porpoise in the SNS SAC (JNCC et al., 2020) is that:

"Noise disturbance within an SAC from a plan/project individually or in-combination is considered to be significant if it excludes harbour porpoise from more than:

- 20% of the relevant area of the site in any given day, or
- An average of 10% of the relevant area of the site over a season."

6.2.2.3 Conservation Objective 3: The condition of supporting habitats and processes, and the availability of their prey is maintained.

274. Supporting habitats, in this context, means the characteristics of the seabed and water column. Supporting processes encompass the movements and physical properties of the habitat. The maintenance of these supporting habitats and processes contributes to ensuring prey is maintained within the site and is available to harbour porpoise using the SAC. Harbour porpoise are strongly reliant on the availability of prey species year round due to their high energy demands, and their distribution and condition may strongly reflect the availability and energy density of prey.

275. This Conservation Objective is designed to ensure that harbour porpoise are able to access food resources year round, and that activities occurring in the SNS SAC will not affect this.

6.2.3 Shadow appropriate assessment

276. The North Falls array area is located within the SNS SAC and therefore there is potential for LSE on its designated feature, harbour porpoise, during construction, O&M or decommissioning of North Falls. This resulted in the SNS SAC being screened into the assessment through the Habitats Regulations Assessment Screening Report (Appendix 1).

277. For the purposes of the assessments, the potential effects considered in relation to the SNS SAC Conservation Objectives are outlined in Table 6.6.

Table 6.6 Potential Effects of North Falls in Relation to the Conservation Objectives of the SNS SAC for Harbour Porpoise

Conservation Objective for harbour porpoise	Potential Effect
Harbour porpoise is a viable component of the site	Physical and permanent auditory injury from underwater noise will be mitigated but in line with current advice this is screened in.
	Significant disturbance and displacement as a result of increased underwater noise levels has the potential to have an adverse effect on harbour porpoise from the SNS SAC and will be considered further.
	Any potential increased collision risk with vessels could cause a potential LSE which will be considered further.
There is no significant disturbance of the species	Significant disturbance and displacement as a result of increased underwater noise levels has the potential to have an adverse effect on harbour porpoise from the SNS SAC and will be considered further.
The condition of supporting habitats and processes, and the availability of prey is maintained	Changes in water quality and prey availability have the potential to affect the harbour porpoise from the SNS SAC and will be considered further.

278. The potential effects of North Falls that are assessed to determine any potential for an adverse effect on the integrity of the SNS SAC in relation to the Conservation Objectives for harbour porpoise are:

- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during piling;
- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during UXO clearance;
- Disturbance impacts resulting from underwater noise during other construction activities, including seabed preparations, rock placement and cable installation;
- Potential effects resulting from construction vessels:
    - Underwater noise and disturbance from construction vessels; and
    - Vessel interaction (collision risk);
- Barrier effects as a result of underwater noise;
- Changes to prey availability and supporting habitats;
- Changes to water quality; and
- In-combination effects.

279. Assessment of the potential effects on the SNS SAC for harbour porpoise, is based on the current SNCB advice (JNCC *et al.,* 2020) that noise disturbance within an SAC from a plan/project, individually or in-combination, is considered to be significant if it excludes harbour porpoises from more than:

- 20% of the relevant area of the site in any given day, or
- an average of 10% of the relevant area of the site over a season.

280. The potential effect should be considered in the context of the seasonal components of the SAC area, rather than the SAC area as a whole.

281. The assessments are based on the current recommended EDRs for assessing the disturbance of harbour porpoise in the SAC from different noise generating activities (JNCC et al., 2020).

6.2.3.1 Potential effects during construction

6.2.3.1.1 Impact 1: Potential effects of underwater noise during piling

282. A range of foundation options are being considered for North Falls. Of these being considered, monopiles and jackets (pin-piles) may require piling. As a worst-case scenario for underwater noise, it has been assumed that all foundations could be piled.

283. Impact piling is a source of high-level underwater noise. Underwater noise can cause both physiological (e.g. lethal, physical injury and auditory injury) and behavioural (e.g. disturbance and masking of communication) impacts on marine mammals.

Impact 1a: Permanent Auditory Injury (PTS)

284. Underwater noise modelling was carried out by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during noisy activities and determine the potential impacts on marine mammals using the INSPIRE v5.1 (Impulsive Noise Propagation and Impact Estimator) subsea noise propagation model (PEIR Appendix 12.2, Volume III).

285. The underwater noise modelling was based on the following worst-case scenarios for monopiles and pin-piles;

- Monopile with a maximum diameter of up to 17m, a maximum hammer energy of up to 6,000kJ, and a maximum starting hammer energy of 900kJ.
- Pin-pile with a maximum diameter of up to 3.5m, a maximum hammer energy of up to 3,000kJ, and a maximum starting hammer energy of 450kJ.

286. To determine the potential for permanent auditory injury (PTS) the soft-start, hammer energy profile, total active piling duration, and strike rate are taken into account. The soft-start takes place over the first 30 minutes of piling, which includes low-energy blows (at the starting hammer energy) for 10 minutes, followed by a gradual increase (ramp-up) to the maximum hammer energy required to safely install the pile.

287. As a worst-case scenario, it is assumed that all piles installed will require 100% of the maximum hammer energy, however, maximum hammer energy is only likely to be required at a few of the piling installation locations, and for shorter periods of time.

288. The low-energy blows, ramp-up, and piling duration used to assess cumulative sound exposure level (SEL_{cum}) for both monopiles and pin-piles are summarised in Table 6.7 and Table 6.8.

Table 6.7 Hammer energy, ramp-up and piling duration for monopiles

Hammer energy / piling parameters	900kJ	1,800kJ	2,700kJ	3,700kJ	4,800kJ	6,000kJ	Total for pile
Hammer energy profile for monopiles							
Number of hammer strikes	100	600	600	600	600	10,800	13,300 strikes over a total duration of 7.5 hours [Or 26,000 strikes over a total duration of 15 hours for two monopiles in a 24 hour period]
Duration of piling at each stage	10 minutes	30 minutes	30 minutes	30 minutes	30 minutes	320 minutes	
Strike rate	10 strikes / minute	20 strikes / minute				Approximately 34 strikes / minute	

Table 6.8 Hammer energy, ramp-up and piling duration for pin-piles

Hammer energy / piling parameters	450kJ	900kJ	1,400kJ	1,900kJ	2,400kJ	3,000kJ	Total for pile
Hammer energy profile for pin-piles							
Number of hammer strikes	100	100	100	100	100	6,120	6,620 strikes over a total duration of 3.5 hours [Or 26,480 strikes over a total duration of 14 hours for four pin-piles in a 24 hour period]
Duration of piling at each stage	10 minutes	5 minutes	5 minutes	5 minutes	5 minutes	180 minutes	
Strike rate	10 strikes / minute	20 strikes / minute				34 strikes / minute	

289. The assessments are based on the latest Southall et al. (2019) thresholds and criteria for marine mammals. The thresholds indicate the onset of PTS, the point at which there is an increase in risk of permanent hearing damage in an underwater receptor (although not all individuals within the maximum PTS range will have permanent hearing damage, this is assumed as a worst-case scenario).

290. The maximum impact ranges (and areas) are used to inform the assessments. The assessment below shows the annual and winter densities only for brevity, PEIR Volume III Appendix 12.3, includes the assessment using the summer seasonal density for harbour porpoise.

PTS from a single strike

291. The underwater noise modelling results for the predicted effect ranges and areas for PTS from a single strike of the maximum hammer energy for the worst case location have been assessed (Table 6.9).

Table 6.9 The predicted effect ranges for PTS, at the worst case modelling location for harbour porpoise, for the maximum hammer energies of both monopiles and pin piles

Marine mammal species	Potential effect ranges (and areas) for PTS at the maximum hammer energy	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Harbour porpoise	680m (1.40km^2)	550m (0.91km^2)

140. An assessment of the maximum number of individuals that could be at risk of instantaneous PTS, due to a single strike at the maximum hammer energy, for both monopiles and jacket pin piles, is presented in Table 6.10.

Table 6.10 Assessment of the potential for instantaneous PTS due to a single strike of the maximum hammer energy for a monopile and jacket pin pile

Marine mammal species	Assessment of effect
PTS due to a single strike of a monopile at maximum hammer energy (Sound pressure level (SPL_{peak}))	
Harbour porpoise	3.0 harbour porpoise (0.0009% of the NS MU reference population, based on the HiDef annual density estimate); or 4.0 harbour porpoise (0.0011% of the NS MU reference population, based on the HiDef winter density estimate).
PTS due to a single strike of a jacket pin pile at maximum hammer energy (SPL_{peak})	
Harbour porpoise	2.0 harbour porpoise (0.0006% of the NS MU reference population, based on the HiDef annual density estimate); or 2.6 harbour porpoise (0.0007% of the NS MU reference population, based on the HiDef winter density estimate).

292. The maximum potential number of harbour porpoise that could be at possible risk of PTS due to a single strike at the maximum hammer energy, for monopiles, without any mitigation is 4 individuals (0.0011% of the NS MU reference population, based on the HiDef winter density estimate). The maximum potential number of harbour porpoise that could be at possible risk of PTS from due to a single strike at the maximum hammer energy, for jacket pin piles, without any mitigation is 2.6 individuals (0.0007% of the NS MU reference population, based on the HiDef winter density estimate).

PTS from cumulative exposure

293. The SEL_{cum} is a measure of the total received noise over the whole piling operation. The SEL_{cum} range indicates the distance from the piling location that if the receptor were to start fleeing in a straight line from the noise source starting at a range closer than the modelled range it would receive a noise exposure in excess of the criteria threshold, and if the receptor were to start fleeing from a range further than the modelled range it would receive a noise exposure below the criteria threshold.

294. Table 6.11 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS due to the cumulative exposure of monopiles and jacket pin piles at the worst case location.

295. It is important to note that assessment for PTS from cumulative exposure is highly precautionary. There is a lot of variation in the potential effect ranges for SEL_{cum} at each location and between locations (PEIR Volume III Appendix

12.2). For example, for harbour porpoise, the PTS effect range for two sequential monopile installations is 3.2km at the East location, and 1.8km at the North location. In addition, the maximum hammer energy is only likely to be required at a few of the piling installation locations and for shorter periods of time.

Table 6.11 The predicted effect ranges for PTS for Harbour porpoise, at the worst case modelling location, for the cumulative exposure of both monopiles and pin piles

Marine mammal species	Potential effect ranges (and areas) for PTS due to cumulative exposure	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Single pile installation in a 24 hour period	One monopile	One jacket pin pile
Harbour porpoise	3.2km (22km^2)	5.1km (56.0km^2)
Multiple sequential pile installations in a 24 hour period	Two sequential monopiles	Four sequential jacket pin piles
Harbour porpoise	3.2km (22km^2)	5.2km (59.0km^2)

296. An assessment of the maximum number of harbour porpoise that could be at risk of cumulative PTS, for both sequential monopiles and jacket pin piles, is presented in Table 6.12, based on the effect areas as presented in Table 6.11.

297. In the worst case. 166.5 individuals 0.048% of the NS MU reference population, based on the HiDef winter density estimate) could be at risk of cumulative PTS due to the cumulative exposure of four sequential jacket pin piles in a 24 hour period.

Table 6.12 Assessment of the potential for PTS due to the cumulative exposure of sequential monopiles or jacket pin piles in a 24 hour period for harbour porpoise

Piling scenario	Assessment of effect
PTS due to the cumulative exposure of two sequential monopiles in a 24 hour period (SELcum)	47.7 harbour porpoise (0.014% of the NS MU reference population, based on the HiDef annual density estimate); or 62.1 harbour porpoise (0.018% of the NS MU reference population, based on the HiDef winter density estimate).
PTS due to the cumulative exposure of four sequential jacket pin piles in a 24 hour period (SELcum)	127.9 harbour porpoise (0.037% of the NS MU reference population, based on the HiDef annual density estimate); or 166.5 harbour porpoise (0.048% of the NS MU reference population, based on the HiDef winter density estimate).

PTS from cumulative exposure from multiple piling locations

298. The simultaneous piling scenario assumes that animals are within potential effect ranges for a much longer period (i.e. they would be travelling from one pile location to another which piling is ongoing), and therefore cumulative effect ranges are much larger than for the cumulative exposure ranges of one pile at a time.

299. The potential effect ranges are not possible to model under this scenario, as there are two starting points for receptors, and it is not possible to determine the potential range at which they need to be in order to not be at risk of effect.

Therefore, the following assessment is based on the potential areas of effect only.

300. Where the potential effect areas are not large enough to interact with each other (i.e. they do not meet), the results for the respective locations and scenarios are used (the results of the modelling for the South and North locations are used to inform the assessment, to align with the modelling locations used for the simultaneous modelling).

301. Table 6.13 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS due to the cumulative exposure of simultaneous monopiles and jacket pin piles at the North and South modelling locations. These locations were chosen as the have the potential for the largest 'spread' in terms of underwater noise propagation (as they are the two furthest apart locations). The modelling includes two monopiles being installed sequentially at each location at the same time, and four jacket pin piles being installed sequentially at each location at the same time.

Table 6.13 The predicted effect ranges for PTS for harbour porpoise at the North and South modelling locations, for the cumulative exposure of multiple monopiles and pin pile installations at the same time

Marine species	Potential effect areas for PTS due to cumulative exposure of simultaneous pile installations	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Multiple sequential pile installations in a 24 hour period (for the East and South modelling locations together)	Two sequential monopiles at the North location and two sequential monopile at the South location	Four sequential jacket pin piles at the North location and four sequential jacket pin piles at the South location
Harbour porpoise	North = 6.8km^2 South = 17km^2 Total together = 23.8km^2	North = 20km^2 South = 49km^2 Total together = 69km^2
Multiple simultaneous pile installations in a 24 hour period (one at the North and one at the South modelling location)	Multiple simultaneous monopiles (two sequential monopiles at each location, at the same time)	Multiple simultaneous jacket pin piles (four sequential jacket pin piles at each location, at the same time)
Harbour porpoise	540.0km^2	620.0km^2

302. An assessment of the maximum number of individuals that could be at risk of cumulative PTS, for simultaneous monopiles and jacket pin piles is presented in Table 6.14, based on the effect areas as presented in Table 6.13.

Table 6.14 Assessment of the potential for PTS due to the cumulative exposure of simultaneous monopiles or jacket pin piles at the same time

Piling scenario	Assessment of effect
PTS due to the cumulative exposure of simultaneous monopile installations (SEL_{cum})	1,170.7 harbour porpoise (0.34% of the NS MU reference population, based on the HiDef annual density estimate); or 1,523.9 harbour porpoise (0.44% of the NS MU reference population, based on the HiDef winter density estimate).

Piling scenario	Assessment of effect
PTS due to the cumulative exposure of simultaneous jacket pin pile installations (SEL_{cum})	1,344.2 harbour porpoise (0.39% of the NS MU reference population, based on the HiDef annual density estimate); or 1,749.6 harbour porpoise (0.5% of the NS MU reference population, based on the HiDef winter density estimate).

Summary for Impact 1a

303. There would be no adverse effect of PTS in harbour porpoise from pile installation on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Impact 1b: Disturbance effects due to piling

304. The range of possible behavioural reactions that may occur as a result of exposure to noise include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour, temporary or permanent habitat abandonment and, in severe cases, panic, or stranding, sometimes resulting in injury or death (Southall et al., 2007).

305. There are currently no agreed thresholds or criteria for the behavioural response and disturbance of marine mammals, therefore it is not possible to conduct underwater noise modelling to predict impact ranges.

306. The current advice from the SNCBs is that an EDR of 26km around piling locations for monopiles (without noise abatement), and 15km for pin piles (with and without noise abatement) is used to determine the area that harbour porpoise may be disturbed from in relevant SAC (JNCC et al., 2020). North Falls is located wholly within the SNS SAC, and therefore this approach has been followed for this assessment. Not all harbour porpoise within these potential disturbance areas based on EDRs will be disturbed, however as a worst case scenario 100% disturbance of harbour porpoise in the areas has been assumed.

307. The estimated number of harbour porpoise and percentage of the North Sea MU reference population that could be disturbed as a result of underwater noise during piling at North Falls is presented in Table 6.15.

308. For a single piling event the worst case would be 1.7% of the NS MU reference population (based on the HiDef winter density estimate) to be at risk of disturbance (Table 6.15). This would be from monopiles.

309. For two simultaneous piling events the worst case would be 3.5% of the NS MU reference population (based on the HiDef winter density estimate) to be at risk of disturbance (Table 6.15). Again, this would be from monopiles. Note that this does not assume any overlap between disturbance areas from the piling events and is therefore precautionary.

Table 6.15 Assessment of the potential for disturbance to harbour porpoise based on the EDR approach for monopiles and jacket pin piles, and for both a single and two simultaneous piling events

EDR	Assessment of effect
For a single piling event	
26km for monopiles	4,604.2 harbour porpoise (1.3% of the NS MU reference population, based on the HiDef annual density estimate); or 5,993.1 harbour porpoise (1.7% of the NS MU reference population, based on the HiDef winter density estimate).
15km for jacket pin piles	1,532.5 harbour porpoise (0.44% of the NS MU reference population, based on the HiDef annual density estimate); or 1,994.8 harbour porpoise (0.58% of the NS MU reference population, based on the HiDef winter density estimate).
For two simultaneous piling events[4]	
26km for monopiles, at two simultaneous locations	9,208.4 harbour porpoise (2.7% of the NS MU reference population, based on the HiDef annual density estimate); or 11,986.0 harbour porpoise (3.5% of the NS MU reference population, based on the HiDef winter density estimate).
15km for jacket pin piles, at two simultaneous locations	3,065.1 harbour porpoise (0.88% of the NS MU reference population, based on the HiDef annual density estimate); or 3,990.0 harbour porpoise (1.2% of the NS MU reference population, based on the HiDef winter density estimate).

Spatial assessment

310. Figure 6.1 and Figure 6.2 show the potential SNS SAC overlaps for a single monopile or pin pile in one day, or for two monopiles or pin piles in one day, respectively.

311. For a single piling event in any one day during the winter season, the spatial threshold (20%) would not be exceeded for either monopiles or jacket pin piles. For two jacket piling events in any one day, the spatial threshold would also not be exceeded. However, for two monopiling events in one day, there is the potential for the spatial threshold to be exceeded.

[4]This assessment does not take account of any potential overlap in disturbance areas

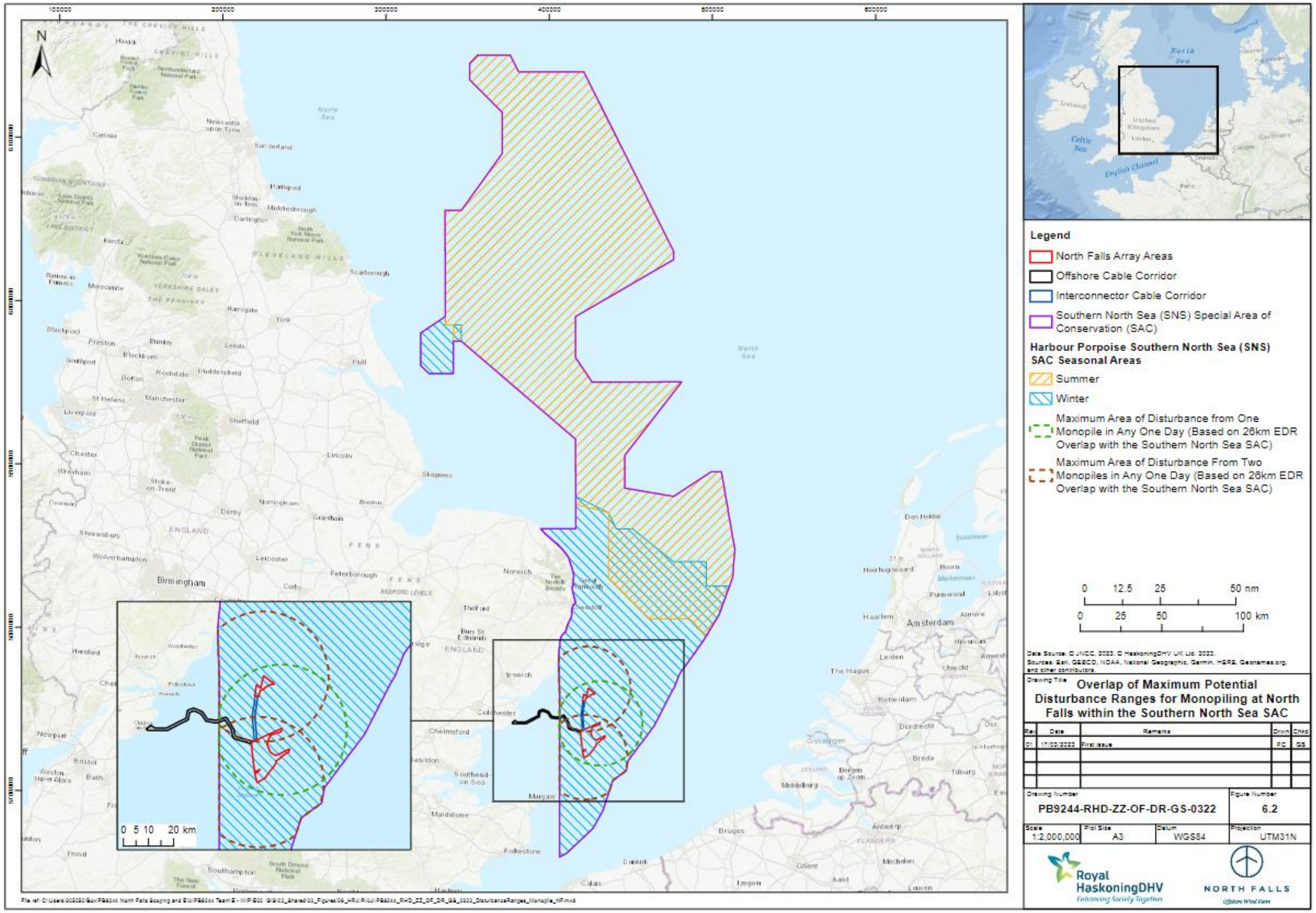

Figure 6.1 Overlap of maximum potential disturbance ranges for monopiling at North Falls within the Southern North Sea SAC

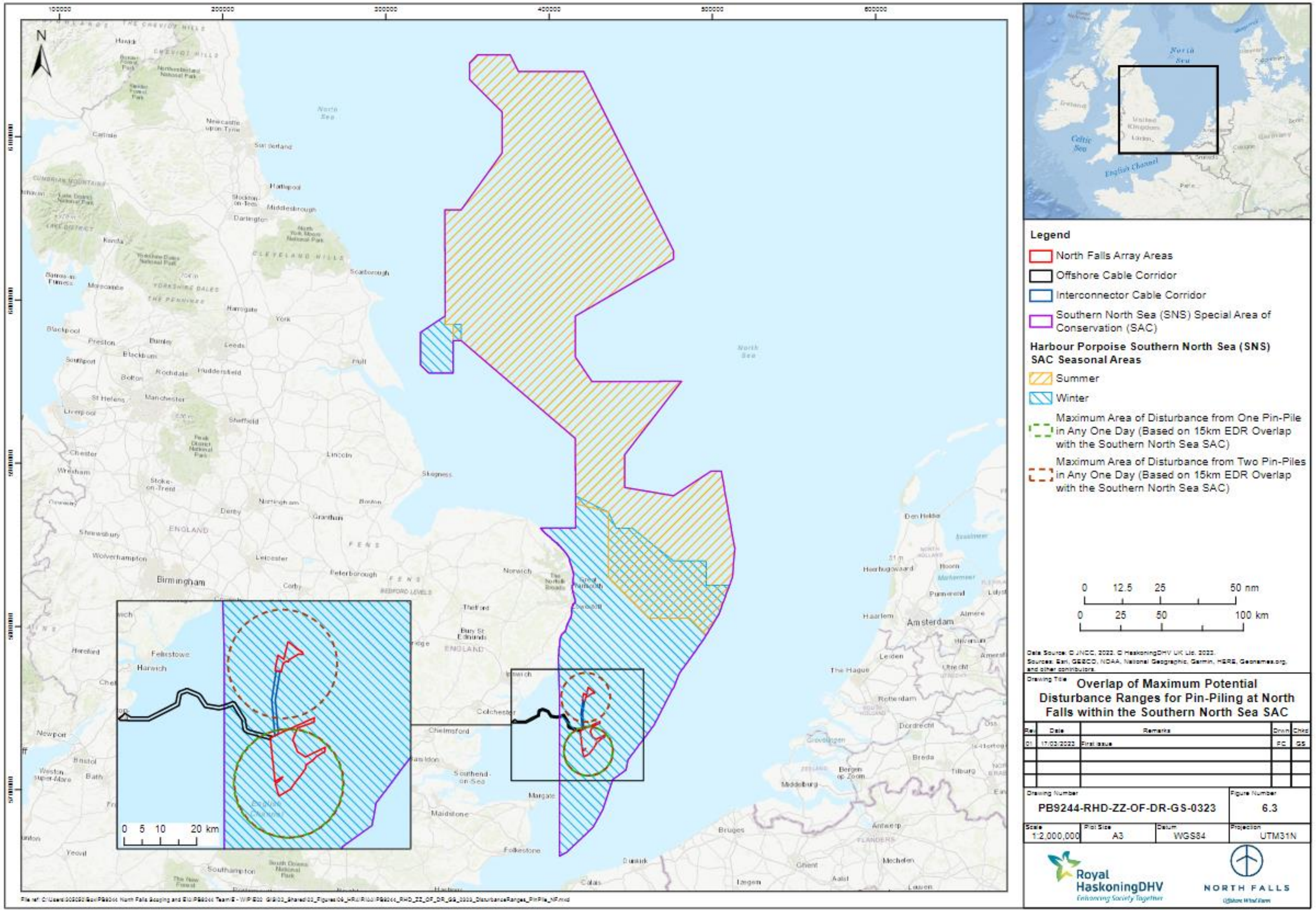

Figure 6.2 Overlap of maximum potential disturbance ranges for pin-piling at North Falls within the Southern North Sea SAC

Table 6.16 Maximum Potential Overlap with SNS SAC Summer and Winter Areas

EDR	Maximum area of overlap with SNS SAC summer area (% of SNS SAC summer area)	Maximum area of overlap with SNS SAC winter area (% of SNS SAC winter area)	Potential adverse effect on site integrity
For a single piling event per day			
26km for monopiles	0km^2	2,109.09km^2 (16.61%)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area on any given day during piling at North Falls based on a single pile per day.
15km for jacket pin piles	0km^2	706.9km^2 (5.57%)	
For two piling events per day[5]			
26km for monopiles, at two locations in one day, with maximum potential separation	0km^2	3,482.20km^2 (27.43%)	Yes
15km for jacket pin piles, at two locations in one day, with maximum potential separation	0km^2	141.38km^2 (11.14%)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area on any given day during piling at North Falls based on a single pile per day.

Seasonal average

312. The active piling duration could be up to 23.5 days for all monopiles or 56.5 days for pin piles at North Falls. As a precautionary approach, total piling time includes soft-start and ramp-up, and provides allowance for issues such as low blow rate, refusal, etc.

313. Within the following assessment, it has been assumed as a worst-case that one monopile could be installed per day, and therefore there would be a total of 74 piling days within the winter season (for 72 WTGs and two OSPs).

314. For jacket pin piles, it has assumed that for the WTGs, all four jacket piles would be installed at the same time (and therefore the same day). For the OSPs, it has been assumed that the maximum of six piles per foundation would be installed over two days, with four days in total for the two OSPs. This equates to a total of 76 days.

315. The seasonal averages have been calculated by taking into account the maximum potential overlap with SNS SAC seasonal areas on any one day and the estimated maximum number of days within the season on which piling could

[5]This assessment does take account of any potential overlap in disturbance areas

occur. North Falls OWF does not overlap with the summer SNS SAC, however it does overlap with the winter SNS SAC and the winter season is assumed to be 182 days (October-March).

316. The seasonal averages have been based on the precautionary approach that all piling and related disturbance could occur in a single season, and all in the winter season.

317. The assessment indicates less than 10% of the seasonal component of the SNS SAC over the duration of that season could be affected during piling at North Falls, based on the worst-case scenario (Table 6.17).

Table 6.17 Estimated Seasonal Average for SNS SAC Winter Area Based on 26km EDR for North Falls

Piling options	Number of disturbance days per season	Maximum seasonal average for SNS SAC winter area	Potential adverse effect on site integrity
For a single piling event per day			
26km for monopiles	74 days	6.75%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during piling at North Falls, based on the worst-case scenario.
15km for jacket pin piles	76 days	2.33%	
For two piling events per day[6]			
26km for monopiles, at two locations in one day, with maximum potential separation	74 days	11.15%	Yes
15km for jacket pin piles, at two locations in one day, with maximum potential separation	76 days	4.65%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during piling at North Falls, based on the worst-case scenario.

Summary for Impact 1b

318. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC summer or winter area on any given day during

[6]This assessment does take account of any potential overlap in disturbance areas

piling at North Falls, based on the worst-case scenario (Figure 6.2). The assessment indicates less than 10% of the seasonal component of the SNS SAC over the duration of that season could be affected during piling at North Falls, based on the worst-case scenario (Table 6.17). Mitigation measures are under review and will be presented in the Outline SIP and final RIAA to be submitted with the DCO application. NFOW will seek to agree mitigation measures with Natural England and the MMO to ensure there is no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise due to disturbance from piling during construction.

319. Mitigation options under review include, *inter alia,* minimising piling in the winter months which would reduce disturbance within the winter area of the SAC, within which North Falls is located. A revised assessment, taking account of mitigation will be presented in the final RIAA to be submitted with the DCO application.

Impact 1c: Disturbance effects due to ADD activation

320. The assessments of the potential disturbance during any ADD activation is indicative only, as the final requirements for mitigation in the MMMP will be determined prior to construction.

321. Mitigation to reduce the risk of PTS could include activation of ADDs prior to the soft-start commencing. The period of time that an ADD is required to be activated for is dependent on the potential PTS ranges for each species, and their known swim speeds, as used within the underwater noise modelling.

322. During 10 minutes of ADD activation, harbour porpoise would move at least 0.9km from the ADD location (based on a precautionary marine mammal swimming speed of 1.5m/s; Otani et al., 2000), resulting in a potential disturbance area of 2.55km^2. This is further than the instantaneous PTS range for monopiles predicted for harbour porpoise.

Table 6.18 Assessment of the potential for disturbance due to ADD activation for both monopile and jacket pin piles

Marine mammal species	Assessment of effect
Harbour porpoise	5.5 harbour porpoise (0.002% of the NS MU reference population), based on the HiDef annual density estimate); or 7.2 harbour porpoise (0.002% of the NS MU reference population), based on the HiDef winter density estimate).

323. The ADD activation would ensure marine mammals are beyond the maximum impact range for instantaneous PTS due to a single strike of the maximum hammer energy for both monopiles and jacket pin piles. ADD activation prior to the soft-start would also reduce the number of marine mammals at risk of PTS from cumulative exposure. This disturbance area would be within the disturbance area due to piling (as assessed above), and therefore would not be an additive effect to harbour porpoise.

324. The assessment for the potential for disturbance to harbour porpoise due to ADD activation indicates no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.1.2 Impact 2: Potential effects of underwater noise during other construction activities

325. Potential sources of underwater noise during construction activities, other than piling, include seabed preparation, dredging, rock placement, trenching and cable installation.

326. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd (PEIR Volume III Appendix 12.2) to estimate the noise levels likely to arise during noisy activities, and determine the potential effects on marine mammals.

Impact 2a: Permanent auditory injury (PTS) due to other construction activities

327. Table 6.19 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS from the cumulative exposure of other construction activities. For SEL_{cum} calculations, the duration of the noise is also considered, with all sources operating for a worst case of 12-hours in a day.

328. The results of the underwater noise modelling does not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

Table 6.19 The predicted effect ranges for cumulative PTS for other construction activities in all marine mammal species

Marine mammal species	Potential effect ranges (and areas) for PTS Cable laying, suction dredging, cable trenching, and rock placement*
Harbour porpoise	<100m (0.031km^2)

329. An assessment of the maximum number of individuals that could be at risk of PTS, due to other construction activities, is presented in Table 6.20, based on the effect areas as presented in Table 6.19.

Table 6.20 Assessment of the potential for PTS due to other construction activities, including cable laying, suction dredging, cable trenching, and rock placement, for one activity taking place at any one time

Marine mammal species	Assessment of effect
Harbour porpoise	0.07 harbour porpoise (0.00002% of the NS MU reference population), based on the HiDef annual density estimate; or 0.09 harbour porpoise (0.00003% of the NS MU reference population), based on the HiDef winter density estimate.

330. There is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore export cable or interconnector corridors, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been undertaken.

331. Table 6.21 presents the potential areas of PTS for all four other construction activities taking place at the same time.

Table 6.21 The predicted effect areas for cumulative PTS, for all other construction activities taking place at the same time for harbour porpoise

Marine mammal species	Potential effect areas for PTS Cable laying, suction dredging, cable trenching, and rock placement at the same time
Harbour porpoise	$0.126km^2$

332. An assessment of the maximum number of individuals that could be at risk of PTS, due to all other construction activities undertaken at the same time is presented in Table 6.22, based on the effect areas as presented in Table 6.21.

Table 6.22 Assessment of the potential for PTS due to all other construction activities taking place at the same time

Marine mammal species	Assessment of effect
Harbour porpoise	0.27 harbour porpoise (0.00008% of the NS MU reference population), based on the HiDef annual density estimate; or 0.35 harbour porpoise (0.0001% of the NS MU reference population), based on the HiDef winter density estimate.

333. Given the small number of individuals affected, there would be no adverse effect of PTS in harbour porpoise from other construction activities either alone or taking place simultaneously on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Impact 2b: Disturbance effects due to other construction activities

334. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

335. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance impact on marine mammals.

336. There is limited data on the potential for a behavioural response or disturbance from other construction activities (or other continuous noise sources).

337. Studies undertaken during the construction of two Scottish OWFs (Beatrice OWF and Moray East OWF) (Benhemma-Le Gall et al., 2021), found that the probability of harbour porpoise being present increased with distance from the vessels and construction activities, and decreased with increasing vessel presence and background noise. During the period of turbine installation at Beatrice OWF, a significant reduction in harbour porpoise presence was detected even while no piling was taking place. Various construction activities were undertaken during this turbine installation phase, including jacket installation, turbine and cable installations, with some activities occurring simultaneously, which led to high levels of vessel traffic within the OWF site.

338. A reduction in porpoise presence was detected at up to 12km from pile driving, and up to 4km from construction related vessels (Benhemma-Le Gall et al., 2021). With construction vessels at 2km from Cetacean Porpoise Detector (CPOD) locations, harbour porpoise activity decreased by up to 35.2%, with construction vessels at 3km from the CPODs, there was a decrease of up to 24%, and at 4km from construction vessels, there was an increase of 7.2%. Outside of the piling period, the study found that the presence of harbour porpoise decreased by 17% with SPLs of 57dB (above ambient noise). It was not possible to determine what activities were being undertaken by the construction vessels in order to determine what activity was causing this effect (Benhemma-Le Gall et al., 2021).

339. While the study did not define which activities were taking place to cause the disturbance, it was while a number of construction vessels were on site (Benhemma-Le Gall et al., 2021). Therefore, this reported 4km reduction in harbour porpoise presence has been used as a potential disturbance range for other construction activities in this assessment.

Disturbance due to other construction activities (for a single activity)

340. An assessment of the maximum number of individuals that could be at risk of disturbance due to other construction activities based on the 4km potential disturbance range (with an effect area of 50.3km^2) is presented in Table 6.23.

Table 6.23 Assessment of the potential for disturbance due to other construction activities, including cable laying, suction dredging, cable trenching, and rock placement, for one activity taking place at any one time

Marine mammal species	Assessment of effect
Harbour porpoise	109.0 harbour porpoise (0.03% of the NS MU reference population), based on the HiDef annual density estimate; or 141.8 harbour porpoise (0.04% of the NS MU reference population), based on the HiDef winter density estimate.

Spatial assessment

341. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC winter area on any given day during other construction activities for a single activity at North Falls, based on the worst-case scenario (Table 6.24). Therefore, there is no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise due to disturbance from other construction activities during construction, for North Falls.

Table 6.24 Maximum Potential Overlap with SNS SAC Summer and Winter Areas Based on the potential disturbance range of 4km for North Falls

Maximum area of overlap with SNS SAC winter area (% of SNS SAC winter area)	Potential adverse effect on site integrity
50.3km^2 (0.4%)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC

Maximum area of overlap with SNS SAC winter area (% of SNS SAC winter area)	Potential adverse effect on site integrity
	area on any given day during piling at North Falls based on the worst-case scenario.

<u>Seasonal average</u>

342. The seasonal averages have been calculated by taking into account the maximum potential overlap with SNS SAC seasonal areas on any one day by the estimated maximum number of days within the season on which other construction activities could occur. In this case, it is assumed that construction could occur throughout the whole winter season (182 days)

343. The assessment indicates less than 10% of the seasonal component of the SNS SAC over the duration of that season could be affected during other construction activities for a single activity at North Falls, based on the worst-case scenario (Table 6.25**).** Therefore, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise due to disturbance from other construction activities during construction for North Falls.

Table 6.25 Estimated Seasonal Average for SNS SAC Winter Area Based on disturbance range of 4km for North Falls

Number of disturbance days per season	Maximum seasonal average for SNS SAC winter area	Potential adverse effect on site integrity
182 days	0.4%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during piling at North Falls, based on the worst-case scenario.

Disturbance due to other construction activities at multiple simultaneous locations

344. As noted above, there is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore export cable or interconnector corridors, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been undertaken.

345. Based on a 4km potential disturbance range, and up to four other construction activities taking place at the same time, there is the potential for a simultaneous disturbance effect area of 201.06km^2 for all marine mammal species. As noted above, this assumes that the disturbance would only affect the area around the vessel at the time of the activity taking place, and that marine mammals would return to the disturbed area once the activity had either completed or transited to a new location.

346. An assessment of the maximum number of individuals that could be at risk of disturbance, due to all other construction activities undertaken at the same time is presented in Table 6.26.

Table 6.26 Assessment of the potential for disturbance due to all other construction activities taking place at the same time

Marine mammal species	Assessment of effect
Harbour porpoise	435.9 harbour porpoise (0.13% of the NS MU reference population), based on the HiDef annual density estimate; or 567.4 harbour porpoise (0.16% of the NS MU reference population), based on the HiDef winter density estimate.

Spatial assessment

347. Disturbance of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC winter area on any given day during other construction activities at multiple simultaneous locations at North Falls, based on the worst-case scenario (Table 6.27). Therefore, under these circumstances, there is no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise due to disturbance from piling during construction, for North Falls.

Table 6.27 Maximum Potential Overlap with SNS SAC Winter Area Based on disturbance effect area of 201.06km^2 for North Falls

Maximum area of overlap with SNS SAC winter area (% of SNS SAC winter area)	Potential adverse effect on site integrity
201.06km^2 (1.58%)	No Temporary effect. Displacement of harbour porpoise would not exceed 20% of the seasonal component of the SNS SAC area on any given day during piling at North Falls based on the worst-case scenario.

Seasonal average

348. The seasonal averages have been calculated by taking into account the maximum potential overlap with SNS SAC seasonal areas on any one day by the estimated maximum number of days within the season on which other construction activities could occur.

349. The assessment indicates less than 10% of the seasonal component of the SNS SAC over the duration of that season could be affected during other construction activities at multiple simultaneous locations at North Falls, based on the worst-case scenario (Table 6.28). Therefore, under these circumstances, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise due to disturbance from other construction activities taking place simultaneously during construction, for North Falls.

Table 6.28 Estimated Seasonal Average for SNS SAC Winter Area Based on disturbance effect area of 201.06km^{2}for North Falls

Number of disturbance days per season	Maximum seasonal average for SNS SAC winter area	Potential adverse effect on site integrity
182 days	1.58%	No Temporary effect. Displacement of harbour porpoise would not exceed 10% of the seasonal component of the SNS SAC over the duration of that season during piling at North Falls, based on the worst-case scenario.

6.2.3.1.3 Impact 3: Effects from underwater noise and disturbance associated with construction vessels

350. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise due to vessel presence and determine the potential effects on marine mammals (PEIR Volume III Appendix 12.2).

Impact 3a: Permanent auditory injury (PTS) due to construction vessels

351. Table 6.29 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS from the cumulative exposure of vessels within the site. For SEL_{cum} calculations, the duration of the noise is also considered, with noise present for a worst case of 24-hours in a day.

352. The results of the underwater noise modelling does not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

353. The results of the underwater noise modelling (Table 6.29) indicate that any harbour porpoise would have to be <100m (precautionary maximum range) from the continuous noise source for 24 hours, to be exposed to noise levels that could induce PTS. It is therefore highly unlikely that any individual would be at risk of PTS due to vessel noise. It should be noted that the predicted impact ranges are the distances which represent the 'onset' stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 6.29 The predicted effect ranges for cumulative PTS for vessels in all marine mammal species

Marine mammal species	Potential effect ranges (and areas) for PTS Medium or large vessels*
Harbour porpoise	<100m (0.031km^2)

354. An assessment of the maximum number of individuals that could be at risk of PTS, due to other construction activities, is presented in Table 6.30, based on the effect areas as presented in Table 6.29.

355. Given the small number of individuals affected, there would be no adverse effect of PTS in harbour porpoise from vessels on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Table 6.30 Assessment of the potential for PTS due to medium and large vessels

Marine mammal species	Assessment of effect
Harbour porpoise	0.07 harbour porpoise (0.00002% of the NS MU reference population), based on the HiDef annual density estimate; or 0.09 harbour porpoise (0.00003% of the NS MU reference population), based on the HiDef winter density estimate.

356. There is the potential that up to 35 vessels may be present in the North Falls site at any one-time during construction. As a worst case and unlikely scenario, an assessment for all 35 vessels has also been undertaken.

357. Table 6.31 presents the potential areas of PTS for the maximum construction vessels at any one time, of 35 vessels.

Table 6.31 The predicted effect areas for cumulative PTS, for multiple construction vessels for all marine mammal species

Marine mammal species	Potential effect areas for PTS
Harbour porpoise	1.1km^2

358. An assessment of the maximum number of individuals that could be at risk of PTS, due to the maximum number of construction vessels at any one time is presented in Table 6.32, based on the effect areas as presented in Table 6.31.

Table 6.32 Assessment of the potential for PTS due to multiple construction vessels

Marine mammal species	Assessment of effect
Harbour porpoise	2.4 harbour porpoise (0.0007% of the NS MU reference population), based on the HiDef annual density estimate; or 3.1 harbour porpoise (0.0009% of the NS MU reference population), based on the HiDef winter density estimate.

359. Given the small number of individuals affected, there would be no adverse effect of PTS in harbour porpoise from vessels on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Impact 3b: Disturbance effects due to construction vessels

360. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

361. There is the potential for sensitive species with high metabolic requirements, such as the harbour porpoise, to be more vulnerable to anthropogenic stressors such as vessel noise, forcing individuals to make trade-off decisions between using energy to leave the area or remaining in exposed areas (Benhemma-Le Gall et al., 2021). This additional energy use may have biological consequences in the short and long-term (Pirotta et al. 2014), and harbour porpoise have been

shown to be displaced by vessel activity up to 7km away depending on vessel type (Wisniewska et al., 2018). In a 2012 study, high-speed planing vessels (small boats, jet skis etc.) caused the most negative reactions in this species (Oakley et al., 2017).

362. Whilst short to medium term behavioural responses have been recorded from vessel disturbance, there are no long-term or population level effects recorded to date. Therefore it is considered that there would be no adverse effect from disturbance from underwater noise associated with vessels on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.1.4 Impact 4: Barrier effects from underwater noise during construction

363. The greatest potential barrier effect for marine mammals could be from underwater noise during piling. Piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles, and if installed in groups there could be time periods when piling is not taking place as piles are brought out to the site. There will also be potential delays for weather or other technical issues.

364. The maximum duration of any barrier effects would be for the maximum piling duration, based on worst case scenarios, including soft-start, ramp-up and ADD activation.

365. There is unlikely to be the potential for any barrier effects from underwater noise for other construction activities and vessels, as it is predicted that harbour porpoise will return once the activity has been completed, and therefore any effects from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any barrier effects that could significantly restrict the movements of marine mammals.

366. There is unlikely to be any significant long-term impacts from any barrier effects, as any areas affected would be relatively small in comparison to the range of harbour porpoise and would not be continuous throughout the offshore construction period.

367. Any potential barrier effects as a result of underwater noise during construction have been assessed as having no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.1.5 Impact 5: Increased risk of collision with vessels during construction

368. Marine mammals are able to detect and avoid vessels. However, vessel strikes are known to occur, possibly due to distraction whilst foraging and socially interacting, or due to the marine mammals' inquisitive nature (Wilson et al., 2007). Therefore, increased vessel movements, especially those outside recognised vessel routes, can pose an increased risk of vessel collision to marine mammals.

369. Studies have shown that larger vessels are more likely to cause the most severe or lethal injuries, with vessels over 80m in length causing the most damage to marine mammals (Laist et al., 2001). Vessels travelling at high speeds are considered to be more likely to collide with marine mammals, and those travelling at speeds below 10 knots would rarely cause any serious injury (Laist et al., 2001).

370. Harbour porpoises are small and highly mobile, and given their responses to vessel noise (e.g. Thomsen et al., 2006; Polacheck and Thorpe, 1990), are expected to largely avoid vessel collisions. The Heinänen and Skov (2015) report indicates a negative relationship between the number of ships and the distribution of harbour porpoise in the North Sea, suggesting that the species could exhibit avoidance behaviour which reduces the risk of strikes.

371. Predictability of vessel movement by marine mammals is known to be a key aspect in minimising the potential risks imposed by vessel traffic (Nowacek et al., 2001, Lusseau, 2003, 2006).

372. Collision risk is assessed in Chapter 12 of the PEIR (Section 12.6.1.5, Volume I) and the methodology has been applied to this assessment. To inform this assessment, the total number of each marine mammal species in UK waters has been compared against the total vessels present in UK waters, as well as the potential collision risk rate of each species based on Scottish Marine Animal Stranding Scheme (SMASS) and Cetacean Strandings Investigation programme data. The total UK populations are taken from IAMMWG (2022). The total presence of vessels in UK waters is taken from the total vessel transits within the 2015 Automatic Information System (AIS) data, which is the latest publicly available.

373. To estimate the potential collision risk of vessels associated with North Falls during construction, the potential risk rate per vessel has been calculated for all relevant species, which is then used to calculate the total risk to marine mammal species due to the presence of an additional 35 vessels at any one time during construction. The baseline conditions indicate an already relatively high level of shipping activity in and around the array areas, with an average of 151 vessels per day in winter, and 167 in summer.

374. It is estimated that 3.1 harbour porpoise (0.0009% of the reference population) could be at risk of collision (see Table 12.63 of Chapter 12 of the PEIR, Volume I). This is a highly precautionary assumption, as it is unlikely that marine mammals in the offshore project area would be at increased collision risk with vessels during construction, considering the minimal number of vessel movements compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

375. In addition, vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Vessel operators will use best practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever possible.

376. Any increase in vessel collision risk during construction has been assessed as having no adverse effect on the integrity of the SNS SAC.

6.2.3.1.6 Impact 6: Potential effects of changes to prey availability and habitat quality

377. The potential effects on prey species during construction can result from physical disturbance and loss of seabed habitat; increased SSC and sediment re-deposition; and underwater noise. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of these impact pathways on the

relevant fish and shellfish species and concludes impacts of negligible to minor adverse significance in EIA terms.

378. During construction activities, the worst-case footprint for disturbance would be 6.1km^2, constituting only 0.000017% of the total SNS SAC area. Predominantly medium and coarse-grained sediment type were found at North Falls (see Chapter 8 Marine Geology, Oceanography and Physical Processes, Volume I), typically remaining close to the seabed and settling quickly once disturbed. The worst-case level of sediment smothering and deposition would be approximately <1mm, short-lived (minutes) and localised. Increases in suspended sediment are therefore expected to cause localised and short-term increases in SSC only and not significantly affect fish species.

379. The data and analysis in PEIR Chapter 9 Marine Water and Sediment Quality (Volume I) indicates that levels of contaminants within the North Falls offshore site are low and do not contain elevated levels to cause concern.

380. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I), provides an assessment of the potential underwater noise impacts on fish and shellfish species and predicts that impacts would be of a temporary nature (see Chapter 11 (Volume I) for a detailed assessment of underwater noise impacts on fish species). Potential sources of underwater noise and vibration during construction include piling, increased vessel traffic, seabed preparation, rock placement and cable installation. Of these, piling is considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse impacts on fish.

381. Piling could have mortality/injury effects, but under a realistic fleeing animal assumption, ranges at which mortality/potential mortal injury and recoverable injury could occur would be reduced to less than 100m (see PEIR Chapter 11 (Volume I) Table 11.21 to 11.34). Therefore, any effect on prey populations would be highly localised.

382. The outputs of the underwater noise modelling for the spatial worst-case scenario indicate that TTS may occur at distances up to 16km and 17km assuming a fleeing animal fleeing animal (single pin pile and sequential pin pile installation), increasing to up to 33km and 39km when considering a stationary receptor (single monopile and sequential monopiles installation). Behavioural responses would be expected within these ranges and potentially in wider areas depending on the hearing ability of the species under consideration (see PEIR Chapter 11 (Volume I) Table 11.21 to 11.34). However, the potential for behavioural response does not indicate that prey would actually leave the area (and in many cases this would not be possible within the duration of a piling event).

383. It is unlikely that there would be significant changes to prey over the entire area. It is more likely that effects would be restricted to an area around the working sites. There is unlikely to be any additional displacement of harbour porpoise as a result of any changes in prey availability during piling as harbour porpoise would also be disturbed from the area.

384. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of the potential changes of fishing activity by the presence of safety zones associated with the project during construction. The predicted impact

would be of negligible impact given the short-term and temporary nature of the construction phase.

385. The footprint of the project is relatively small with regard to the entire area of the SNS SAC and so the effects of changes to prey, possibly arising during construction activities, would have no adverse effects on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise for North Falls.

6.2.3.1.7 Impact 7: Potential effects of changes to water quality

386. Potential changes in water quality during construction could occur through:

- Deterioration in water quality due to an increase in suspended sediment associated with seabed preparation for the installation of foundations, array, and interconnector cables;
- Deterioration in water quality due to an increase in sediment concentrations due to drill arisings for installation of piled foundations for wind turbines and OSP;
- Deterioration in water quality due to increases in suspended sediment associated with the installation of the offshore export cable; and
- Deterioration in water quality associated with release of sediment bound contaminants.

387. North Falls are committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction activities. As a result, an outline PEMP will be developed to accompany the DCO application. The final PEMP would be agreed with the MMO prior to construction and would include, for example, measures to control accidental release of drilling fluids whilst ensuring that any chemicals used are listed on the OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) (OSPAR, 2021).

388. Marine mammals often inhabit turbid environments and cetaceans utilise sonar to sense the environment around them and there is little evidence that turbidity affects cetaceans directly (Todd et al., 2014).

389. Increased turbidity is unlikely to have a direct impact on marine mammals that often inhabit naturally turbid or dark environments. This is likely because other senses are utilised, and vision is not relied upon solely.

390. Potential changes in water quality during construction would have no adverse effects on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise for North Falls.

6.2.3.2 Potential effects during O&M

391. The potential effects during O&M that have been assessed for are:

- Auditory injury and disturbance or behavioural impacts resulting from operational WTGs;
    - Permanent auditory injury (PTS).
    - Disturbance.

- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during maintenance activities, including cable protection and cable reburial;
    - Permanent auditory injury (PTS).
    - Disturbance.
- Impacts resulting from the deployment of O&M vessels:
    - Underwater noise and disturbance from O&M vessels;
        - Permanent auditory injury (PTS).
        - Disturbance.
- Vessel interaction (collision risk).
- Barrier effects as a result of underwater noise;
- Changes to water quality; and
- Changes to prey resource and habitat quality.

6.2.3.2.1 Impact 1; Impacts from underwater noise associated with operational WTGs

392. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during the operational phase and determine the potential effects on marine mammals (PEIR Appendix 12.2, Volume III).

Impact 1a: Permanent auditory injury (PTS) due to operational wind turbine noise

393. Table 6.33 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS from the cumulative exposure of operational WTGs. For SEL_{cum} calculations, the duration of the noise is also considered, with operating WTGs for a worst case of 24-hours in a day.

394. The results of the underwater noise modelling does not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

395. It is important to note that PTS is unlikely to occur in marine mammals, as the modelling indicates that the marine mammal would have to remain <100m from a WTG for 24 hours for any potential risk of PTS (Table 6.33). Therefore, PTS as a result of operational WTG noise is highly unlikely. It should be noted that the predicted impact ranges are the distances which represent the ‘onset’ stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

Table 6.33 The predicted effect ranges for cumulative PTS due to operational WTGs

Marine mammal species	Potential effect ranges (and areas) for PTS
Harbour porpoise	<100m (0.031km^2)

396. The maximum number of individuals that could be at risk of PTS, due to a single operational WTG, is 0.07 harbour porpoise (0.00002% of the NS MU reference population), based on the HiDef annual density estimate; or 0.09 harbour porpoise (0.00003% of the NS MU reference population), based on the HiDef winter density estimate.

397. More than one WTG will be operating at the same time, and therefore an assessment of the potential for auditory injury, due to all operational WTGs, is required. There is the potential for either 72 of the smallest WTGs, or 40 of the largest WTGs to be installed for the North Falls project. The potential auditory effect ranges are the same for the range of WTGs included in the North Falls design envelope, and therefore the worst case would be for a total of 72 operational WTGs.

398. The potential areas of PTS for all operational WTGs for harbour porpoise is 2.26km^2.

399. The indicative separation distance between WTGs would be a minimum of 0.82km to 1.685km, depending on WTG size, therefore there would be no overlap in the potential impact range of <100m (<0.1km) around each WTG.

400. An assessment of the maximum number of individuals that could be at risk of PTS from all operational WTGs is 4.9 harbour porpoise (0.0014% of the NS MU reference population), based on the HiDef annual density estimate; or 6.4 harbour porpoise (0.002% of the NS MU reference population), based on the HiDef winter density estimate.

401. There would be no adverse effect of PTS in harbour porpoise from operational WTG noise on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Impact 1b: Disturbance effects due to operational wind turbine noise

402. Currently available data indicates that there is no lasting disturbance or exclusion of harbour porpoise around OWF sites during operation (Diederichs et al., 2008; Lindeboom et al., 2011; Marine Scotland, 2012; McConnell et al., 2012; Russell et al., 2014; Scheidat et al., 2011; Teilmann et al., 2006; Tougaard et al., 2005, 2009a, 2009b). Data collected suggests that any behavioural responses for harbour porpoise may only occur up to a few hundred metres away (Touggard et al., 2009b; McConnell et al., 2012).

403. Monitoring was carried out at the Horns Rev and Nysted OWFs in Denmark during the operation between 1999 and 2006 (Diederichs et al., 2008). Numbers of harbour porpoise within Horns Rev were slightly reduced compared to the wider area during the first two years of operation, however, it was not possible to conclude that the OWF was solely responsible for this change in abundance without analysing other dynamic environmental variables (Tougaard et al., 2009a). Later studies by Diederichs et al. (2008) recorded no noticeable effect on the abundances of harbour porpoise at varying wind velocities at both of the OWFs studied, following two years of operation.

404. Harbour porpoise have been shown to forage within operational OWFs (e.g. Lindeboom et al., 2011; Russell et al., 2014), indicating no restriction to movements in operational OWF sites.

405. For the potential for disturbance due to operational WTGs, the effect significance has been assessed as having no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.2.2 Impact 2: Impacts from underwater noise associated with O&M activities

406. The requirements for any potential O&M work, such as additional rock placement or cable re-burial, are currently unknown, however the work required, and associated effects to marine mammals would be less than those during construction.

407. The potential for PTS is only likely in very close proximity to cable laying or rock placement activities, and if the marine mammal remains within close proximity for 24 hours. Therefore, it is highly unlikely for there to be any PTS due to these activities.

408. The effects from additional cable laying and protection are temporary in nature and will be limited to relatively short periods during the O&M phase. Disturbance responses are likely to occur at significantly shorter ranges than construction noise. Any disturbance is likely to be limited to the area in and around where the actual activity is taking place. The requirements for any potential maintenance work are currently unknown, however, the work required, and impacts associated with underwater noise and disturbance from activities during O&M would be less than those during construction. As there is expected to be less noisy activities during the operation phase than is required during construction, it is therefore likely to cause less disturbance to foraging behaviours in harbour porpoise.

409. Therefore, the potential for adverse effect due to underwater noise from O&M activities is considered to be the same or less than that assessed for underwater noise from other construction activities (including rock placement, trenching and cable laying) (as assessed in Section 6.2.3.1.2).

410. The effect significance for permanent changes in hearing sensitivity (PTS) due to these operational activities has therefore been assessed as having no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.2.3 Impact 3: Impacts from underwater noise and disturbance associated with O&M vessels

Impact 3a: Auditory injury due to O&M vessels

411. During the O&M of North Falls, there could be up to 1,587 vessel round-trips per year (approximately 3.3 trips per day), representing an increase of up to 4% compared to average daily vessels in summer, and up to 4.4% compared to the daily vessels in winter.

412. During operation, there may be up to 22 vessels in the North Falls project area at any one time, compared to the 35 vessels that would be on site during construction. Therefore, the potential effects associated with underwater noise and disturbance from vessels during O&M would be less than of those during construction (as assessed in Section 6.3.3.1.3). As a precautionary approach the assessment for construction has been used for the O&M assessment, as a worst case scenario.

413. There would therefore be no adverse effect of PTS in harbour porpoise from vessels on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Impact 3b: Disturbance due to O&M vessels

414. The requirements for any potential maintenance work are currently unknown, however the work required, and impacts associated with underwater noise and disturbance from vessels during O&M would be less than those during construction.

415. It is estimated that the maximum number of vessels that could be required on site at any one-time during O&M could be 22, which is less than the 35 vessels that could be on site during construction. However, as a precautionary approach the assessment for construction has been used for the O&M assessment, as a worst case scenario.

416. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of O&M activities will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance effect on marine mammals.

417. There would therefore be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.2.4 Impact 4: Barrier effects from underwater noise during O&M

418. The indicative minimum separation distance between turbines would be a minimum of 0.82km to 1.685km, depending on WTG size, therefore there would be no overlap in the potential impact range (PTS; Table 6.33) of <100m around each turbine, and there would be adequate room for marine mammals to move through the array areas.

419. Harbour porpoise are known to be present and forage within operational wind farm areas (Section 6.2.3.2.1), and therefore it is concluded that the presence of North Falls infrastructure would not form a barrier to any movement of marine mammal species.

420. Therefore, no barrier effects as a result of underwater noise during O&M are anticipated, and no further assessment is required.

6.2.3.2.5 Impact 5: Increased risk of collision with vessels during operation

421. As noted in Section 6.2.3.2.3, it is estimated that the maximum number of vessels that could be required on site at any one-time during O&M could be up to 22, with the potential for up to 1,587 vessel round trips per year.

422. The number of marine mammals at risk of collision, per vessel, in UK waters, has been calculated as described for the construction phase, and has been used to calculate the number of each marine mammal species at risk of collision from the total number of vessel movements per year that are currently expected during the O&M phase. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk.

423. It is estimated that 4.8 harbour porpoise (0.0014% of the reference population) could be at risk of collision (see Table 12.81 of the PEIR). This is a highly precautionary assumption, as it is unlikely that harbour porpoise in the offshore project area would be at increased collision risk with vessels during the O&M phase, considering the minimal number of vessel movements compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

424. In addition, vessel operators will use best practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever possible.

425. Any increase in vessel collision risk during operation has been assessed as having no adverse effect on the integrity of the SNS SAC. This is in relation to the conservation objectives for harbour porpoise.

6.2.3.2.6 Impact 6: Potential effects of changes to prey availability and habitat quality

426. The potential impacts on fish species during O&M can result from temporary habitat loss / disturbance; permanent habitat loss; introduction of wind turbine foundations; scour protection and hard substrate; increased suspended sediments and sediment re-deposition; re-mobilisation of contaminated sediments; underwater noise; and EMF.

427. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of these impact pathways on the relevant fish and shellfish species and concludes impacts of negligible to minor adverse significance in EIA terms. Any impacts on prey species have the potential to affect marine mammals. A summary of the key effects to prey species (and their relevance for harbour porpoise) is provided below.

428. Habitat loss will occur during the lifetime of North Falls as a result of structures, scour and external cable protection installed on the seabed. The introduction of hard substrate, such as wind turbine towers, foundations and associated scour protection and cable protection would increase habitat heterogeneity through the introduction of hard structures in an area predominantly characterised by sediment habitats. During operation of North Falls, the estimated total permanent habitat loss would be up to 6.69km^2 for the array areas and 0.15km^2 for the offshore cable corridor (or a total of 0.019% of the total SNS SAC area). In PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) this is considered minor to negligible, depending on the species in the context of the amount of similar available habitat in the wider area.

429. Increases in SSC within the water column and subsequent deposition onto the seabed may occur as a result of O&M activities. Disturbance caused by jack up vessel legs or anchors, as well as cable reburial and/or repair may result in small volumes of sediment being re-suspended. However, the volumes of sediment disturbed from such activities, as well as the overall duration of the disturbance, would be significantly less compared to construction.

430. The electromagnetic attributes of EMFs have the potential to disrupt organs used for navigation and foraging within a number of fish species. EMFs can

have attractive and repulsive effects, that can cause barrier effects dependent on the species and the spatial scale of EMF, for further information, see Chapter 11 Fish and Shellfish Ecology. The cables will be buried, either within the seabed or under rock protection, resulting in a negligible impact zone for fish and shellfish.

431. The introduction of various man-made structures such as foundations and scour protection in soft sediment areas increases and changes habitat availability and type, resulting in locally altered biodiversity as species are able to establish and thrive in previously hostile environments (Wilhelmsson et al., 2006; Birchenough and Degraer, 2020). Physical structures provide a foundation for settling invertebrates, which increase the organic matter surrounding the structure, and underpin artificial reef ecosystems through 'bottom-up' control of productivity. Increasing nutrient availability and biomass presents opportunities for all fish and shellfish species, from top predators to detritivores (Raoux et al., 2017).

432. The benefit of this potential increase in prey availability to marine mammals has not yet been studied widely. However, the presence of an artificial reef does increase the abundance and biomass of species, and the increase in prey species availability increases the attractiveness of the area to predators (Devault et al., 2017; Paxton et al., 2022). Increasing habitat heterogeneity may benefit harbour porpoise, that have shown to prefer variations in seabed topography (Isojunno et al. 2012, Brookes et al. 2013, Stalder et al. 2020)

433. The introduction of new hard substrate in areas that are predominantly sandy or soft sediments may cause positive effects through potential habitat enhancement (Roach and Cohen, 2020).

434. The effects arising during the operational phase of North Falls are likely to be the same or less than those assessed for construction. The effects of changes to prey during operation would have no adverse effects on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise for North Falls.

6.2.3.2.7 Impact 7: Potential effects of changes to water quality

435. Any risk of accidental release of contaminants will be mitigated in line with the PEMP and any changes to water quality as a result of any accidental release of contaminants leading to potential changes in water quality at North Falls during O&M would be negligible.

436. As previously outlined, changes in water quality are considered to have negligible effect on marine mammals. Therefore, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of any changes to water quality during O&M for North Falls

6.2.3.3 Potential effects during decommissioning

437. Potential effects on harbour porpoise associated with decommissioning have not been assessed in detail, as further assessments will be carried out ahead

of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements. A detailed decommissioning program will be provided to the regulator prior to construction that will give details of the techniques to be employed and any relevant mitigation measures required.

438. Decommissioning would most likely involve the removal of the accessible installed components comprising all of the wind turbine components; part of the foundations (those above seabed level); and the sections of the infield cables close to the offshore structures, as well as sections of the offshore export cables. The process for removal of foundations is generally the reverse of the installation process. There would be no piling, and foundations may be cut to an appropriate level.

439. Potential effects during decommissioning would most likely include:

- Underwater noise and disturbance from decommissioning activities;
- Underwater noise and disturbance from vessels;
- Barrier effects as a result of underwater noise;
- Increased collision risk with vessels;
- Changes to prey resource; and
- Changes to water quality.

440. It is not possible to provide details of the methods that will be used during decommissioning at this time. However, it is expected that the activity levels will be comparable to construction (with the exception of pile driving noise which would not occur).

441. Therefore, the potential effects on harbour porpoise during decommissioning are assumed to be the same or less than those assessed for construction due to the processes of decommissioning potentially being the reverse of the installation, without the need for piling.

6.2.3.4 Potential in-combination effects

442. The following in-combination assessment has been undertaken based on PEIR Volume III Appendix 12.5, and Section 12.9 of PEIR Chapter 12 (Volume I).

443. The in-combination effects assessed are;

- Disturbance from underwater noise due to the following sources;
  - Piling at other OWFs;
  - Construction activities at other OWFs;
  - Geophysical surveys for OWFs;
  - Aggregate extraction and dredging;
  - Oil and gas installation projects;
  - Oil and gas seismic surveys;
  - Subsea cable and pipelines; and

- UXO clearance.

- Barrier effects of other OWFs;
- Increased collision risk with vessels; and
- Changes in prey resource.

6.2.3.4.1 In-combination impact 1: Disturbance from underwater noise

In-combination impact 1a: Assessment of underwater noise from piling at other OWFs

444. A list of UK and European OWF projects that may have the potential for overlapping piling with North Falls is provided in PEIR Chapter 12 (Volume III) (Table 12.87), and has been used to inform the assessment for in-combination effects due to piling at other OWFs.

445. Of the 17 UK and European OWFs screened in for having a construction period that could potentially overlap with the construction of the Project, eight UK OWFs could be piling at the same time, which is currently estimated to take place in 2028 to 2029 and are relevant for harbour porpoise for North Falls;

- Berwick Bank (formally Seagreen Charlie Delta Echo);
- Dudgeon Extension Project (DEP);
- Dunkerque;
- Five Estuaries;
- Hornsea Project Four;
- Outer Dowsing;
- Sheringham Shoal Extension Project (SEP); and
- West Orkney.

446. Of these, only DEP, Five Estuaries, Hornsea Project Four, Outer Dowsing and SEP are within 26km of the SNS SAC, and only Five Estuaries, DEP and SEP are within (or within 26km of) the winter area.

447. This more realistic short list of OWF projects that could be piling at the same time as North Falls could change as projects develop, but this is the best available information at the time of writing, and more accurately reflects the limitations and constraints to project delivery.

448. The commitment to the mitigation agreed through the MMMP for piling would reduce the risk of physical injury or permanent auditory injury (PTS) for all marine mammals.

449. The assessment for harbour porpoise is based on the approach to disturbance as per the current advice from the SNCBs (JNCC et al., 2020) on the assessment of effect on the harbour porpoise designated SACs;

- The potential impact area during single pile installation, based on the 26km EDR for harbour porpoise, with a potential disturbance area of 2,123.7km^2.

450. It should be noted that the potential areas of disturbance assume that there is no overlap in the areas of disturbance between different projects and are

therefore highly conservative (particularly in the case of Five Estuaries and North Falls piling on the same day).

451. The approach to the CEA for piling at OWFs is based on the potential for single piling at each OWF at the same time as single piling at the North Falls. This approach allows for some of the OWFs not to be piling at the same time, while others could be simultaneously piling. This is considered to be the most realistic worst case scenario, as it is highly unlikely that all other OWFs would be simultaneously piling at exactly the same time as piling at North Falls.

452. It is important to note the actual duration for active piling time which could disturb marine mammals is only a very small proportion of the potential construction period, of up to approximately 59 days for North Falls, based on the estimated maximum duration to install individual piles.

453. For harbour porpoise, the potential worst case scenario of other OWFs piling at the same time as North Falls is assessed in Table 6.34. Up to 5.2% of the reference population could potentially be disturbed, however, this is very precautionary, as it is unlikely that all other OWF projects could be piling at exactly the same time as piling at North Falls.

454. In practice, the potential temporary effects would be less than those predicted in this assessment as there is likely to be a great deal of variation in timing, duration, and hammer energies used throughout the various OWF project construction periods. In addition, not all individuals would be displaced over the entire potential disturbance range (26km) used within the assessments. For example, the study of harbour porpoise at Horns Rev (Brandt et al., 2011), indicated that at closer distances (2.5 to 4.8km) there was 100% avoidance, however, this proportion decreased significantly moving away from the pile driving activity and at distances of 10km to 18km avoidance was 32% to 49% and at 21km the abundance was reduced by just 2%.

Table 6.34 Quantitative assessment for in-combination disturbance for harbour porpoise due to piling at other OWFs

Project	SCANS-III Block	Harbour porpoise density (/km^2)	Effect area (km^2)	Maximum number of individuals potentially disturbed during single piling
North Falls	n/a	2.822	2,123.7	5,993.1
Berwick Bank (Seagreen Charlie Delta Echo)	R	0.599	2,123.7	1,272.1
Dudgeon Extension	O	0.888	2,123.7	1,885.8
Dunkerque	L	0.607	2,123.7	1,289.1
Five Estuaries	L	0.607	2,123.7	1,289.1
Hornsea Project Four	O	0.888	2,123.7	1,885.8
Outer Dowsing	O	0.888	2,123.7	1,885.8
Sheringham Shoal Extension	O	0.888	2,123.7	1,885.8

Project	SCANS-III Block	Harbour porpoise density (/km^2)	Effect area (km^2)	Maximum number of individuals potentially disturbed during single piling
West of Orkney	S	0.308	2,123.7	654.1
Total number of harbour porpoise				18,040.8
(without NF)				12,047.8
Percentage of NS MU				5.21%
(without NF)				3.48%

Spatial Assessment

455. Figure 6.3 shows the disturbance area overlaps for all OWFs assessed with the potential for disturbance.

456. For each OWF with the potential for disturbance within the winter area of the SNS SAC, the area of potential effect for single piling that overlaps with the winter areas has been estimated, based on the worst-case scenarios for the maximum, minimum and average overlap.

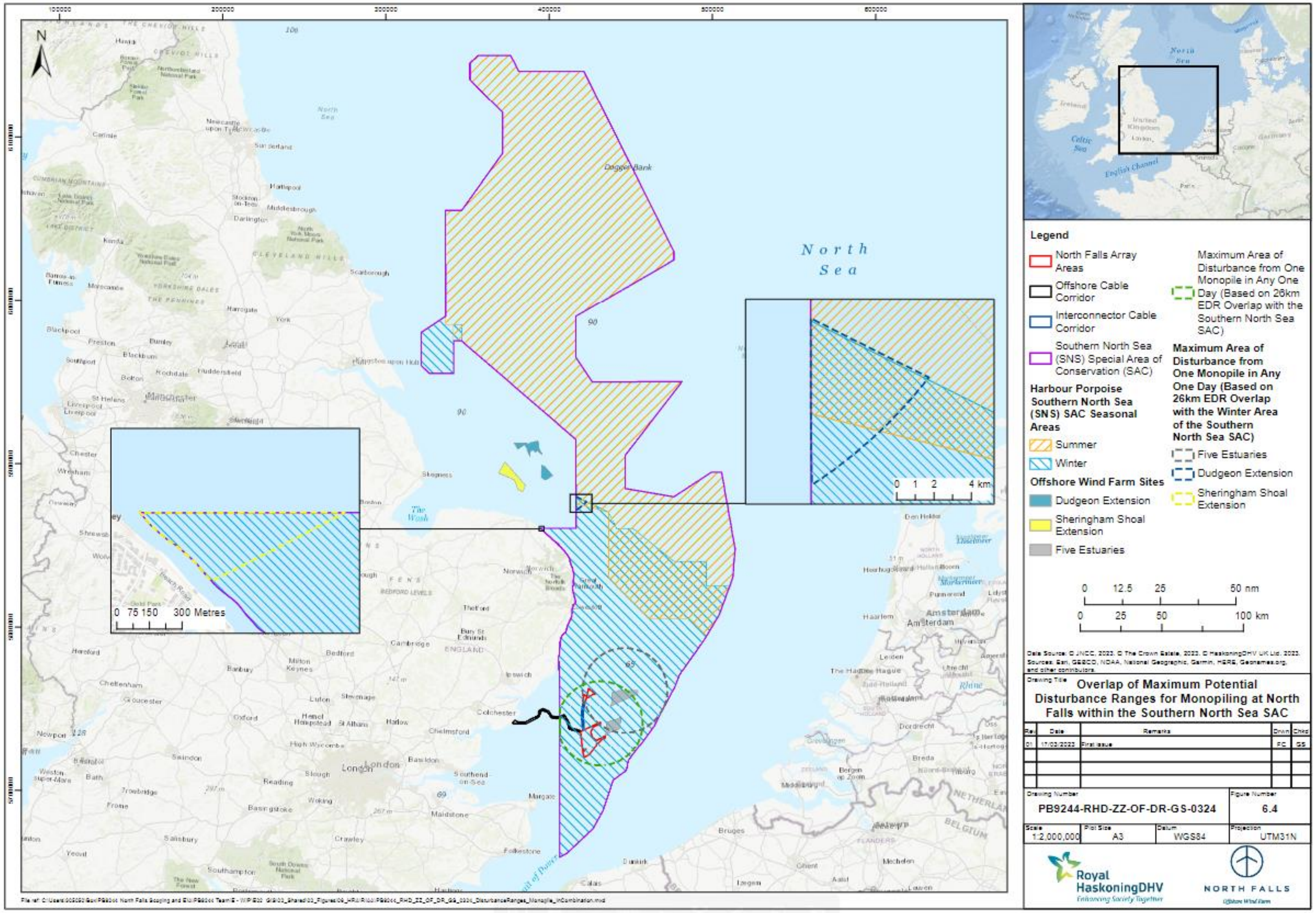

Figure 6.3 Overlap of maximum potential disturbance ranges for monopiling at North Falls within the Southern North Sea SAC

457. The estimated maximum, minimum and average overlap with the SNS SAC summer and winter areas is outlined in Table 6.35.

Table 6.35 Estimated maximum, minimum, and average overlaps with the SNS SAC Winter Area from single piling (26km EDR) at other OWFs on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area	Minimum overlap with seasonal area	Average overlap with seasonal area
Winter area - single piling at other OWFs with mono piling scenario at North Falls			
North Falls	2,109.09 km^2	1,688.37 km^2	1,898.73 km^2
Dudgeon Extension	30.33 km^2	0.00 km^2	15.16 km^2
Five Estuaries	2,123.71 km^2	1,844.75 km^2	1,984.23 km^2
Sheringham Shoal Extension	0.15 km^2	0.00 km^2	0.07 km^2
Total for winter area	4,263.28 km^2 (33.6% of the winter area)	3,533.13 km^2 (27.8% of the winter area)	3,898.19 km^2 (30.7% of the winter area)
Winter area - single piling at other OWFs with pin piling scenario at North Falls			
North Falls	706.85 km^2	682.29 km^2	694.57 km^2
Dudgeon Extension	30.33 km^2	0.00 km^2	15.16 km^2
Five Estuaries	2,123.71 km^2	1,844.75 km^2	1,984.23 km^2
Sheringham Shoal Extension	0.15 km^2	0.00 km^2	0.07 km^2
Total for winter area	2,861.04 km^2 (22.5% of the winter area)	2,527.04 km^2 (19.9% of the winter area)	2,694.03 km^2 (21.2% of the winter area)

458. The assessment indicates that more than 20% of the winter area could be affected, based on the maximum, minimum and average potential overlaps for all OWFs, for both monopile and pin pile scenarios at North Falls (Table 6.35).

459. However, as discussed in Section 6.2.3.1.1, mitigation measures for North Falls are under review and will be presented in the Outline SIP and final RIAA to be submitted with the DCO application.

460. In line with the conclusions of the Review of Consents (RoC) HRA (BEIS, 2020) it is expected that all other OWFs will also have to produce a SIP to ensure that the spatial threshold is not exceeded and there is no significant disturbance and no adverse effect on the integrity of the SNS SAC. This could include the use of noise abatement and reduction measures (which would reduce the EDR to 15km), and / or seasonal restrictions and agreements on when OWF piling could be undertaken.

461. It is also important to note that the in-combination assessments are based on the worst-case for all possible OWFs. As projects develop and programmes are established there will be changes to the potential piling periods for each OWF project. There will also be limitations on the fabrication of wind turbines and the vessels available to install the wind turbine foundations. Therefore, it is unlikely that all OWFs would or could be all piling at the same time.

462. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, it is likely that an adverse effect on the integrity of the SNS SAC will be avoided and this assessment will be reviewed and presented at the DCO application stage.

Seasonal average

463. Seasonal averages have been calculated by multiplying the average effect on any given day in each season by the proportion of days within the season on which piling could occur (i.e. taking into account the average of effect / area of overlap with the SNS SAC and number of days piling per season). Calculations can be seen in Table 6.36.

464. This has been put into the context of the maximum number of piling days for North Falls:

- up to 74 days for the mono piling scenario;
- for up to 76 days for the pin piling scenario.

465. As a worst-case, no allowance has been made for downtime as a result of technical issues and no assumptions have been made for reloading of piling vessels with foundations. The assessment assumes that all piling will be undertaken on the same days as piling at North Falls, therefore this is the maximum number of days on which it is possible for in-combination piling to include North Falls with the maximum spatial overlap of all projects[7].

Table 6.36 Estimated seasonal averages for the SNS SAC Winter Area from single piling at other OWFs which could be piling on the same day as single piling at North Falls

In-combination assessment scenario	Average overlap with seasonal area	Number of piling days for in-combination effects with North Falls	Estimated seasonal average
Winter area, single piling at other OWFs with mono piling scenario at North Falls	30.7%	74	12.48% of winter area
Winter area, single piling at other OWFs with pin piling scenario at North Falls	21.2%	76	8.85% of winter area

466. The assessment indicates based on the worst-case scenarios, the 10% seasonal average threshold could be exceeded for the winter area.

467. However, as discussed in Section 6.2.3.1.1, mitigation measures for North Falls are under review and will be presented in the Outline SIP and final RIAA to be submitted with the DCO application.

[7] Note that Five Estuaries would have between 41 and 79 wind turbines and two platforms. Given the small spatial overlap of DEP and SEP there would in reality be few days on which piling could overlap temporally.

468. All other OWFs will also have to produce a SIP to ensure that the spatial threshold is not exceeded and there is no significant disturbance and no adverse effect on the integrity of the SNS SAC. This could include the use of noise abatement and reduction measures.

469. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, it is likely that an adverse effect on the integrity of the SNS SAC will be avoided and this assessment will be reviewed and presented at the DCO application stage.

In-combination impact 1b: Assessment of underwater noise from construction activities (other than piling) at other OWFs

470. All OWFs with construction dates that have the potential to overlap with the construction dates for North Falls have the potential for other construction activities (such as seabed preparation, dredging, trenching, cable installation, rock placement, drilling and vessels) to occur at the same time as other construction activities at North Falls.

471. OWFs screened in for other construction activities that could have an in-combination effect with other construction activities at North Falls are:

- Aspen (floating);
- Beech North (floating);
- Beech South (floating);
- Dogger Bank South (East and West);
- Dolphyn Project - commercial (floating);
- Dolphyn Project - pre-commercial (floating);
- Dylan (floating); and
- Salamander (floating).

472. While the other OWFs that have been assessed under the in-combination piling assessment have the potential for overlapping construction phases, as well as those listed above, they are already assessed under a worst case of piling overlaps. As the disturbance areas for piling are significantly larger than the disturbance areas for other construction activities, an assessment of piling at those projects would produce a much higher potential for effect than an assessment for in-combination effects with other construction activities, and they are therefore not included under the assessment for other construction activities as set out below.

473. In addition, it is important to consider OWFs that have the potential for disturbance effects to overlap with the SNS SAC. Therefore, OWFs that are within the SNS SAC and included in the in-combination assessment is Dogger Bank South (East and West), which is within the SNS SAC summer area.

474. During the construction of North Falls, there is the potential for overlap with the non-piling construction activities at other OWFs. Noise sources which could cause potential disturbance during OWF construction activities, other than pile

driving, can include vessels, seabed preparation, cable installation works and rock placement.

475. The CEA includes all projects that could have non-piling construction activities during the North Falls construction period.

476. The potential disturbance from OWFs during non-piling construction activities, such as vessel noise, seabed preparation, rock placement and cable installation, has been based on the disturbance area for multiple construction activities taking place at North Falls.

477. For harbour porpoise, based on the worst case scenario, for all OWFs that could be constructing at the same time as North Falls, up to 2.0% of the reference population could be potentially disturbed (Table 6.37).

Table 6.37 Quantitative assessment for in-combination disturbance for harbour porpoise due to construction activities at other OWFs

Project	SCANS-III Block	Harbour porpoise density (/km^2)	Effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls (piling)	n/a	2.822	2,123.7	5,993.1
Aspen (floating)	S & T	0.402	201.1	80.8
Beech North (floating)	T	0.402	201.1	80.8
Beech South (floating)	R	0.599	201.1	120.5
Dogger Bank South (East and West)	O	0.888	201.1	178.6
Dolphyn Project - commercial (floating)	R	0.599	201.1	120.5
Dolphyn Project - pre-commercial (floating)	S & T	0.402	201.1	80.8
Salamander (floating)	R	0.599	201.1	120.5
Dylan (floating)	S & T	0.402	201.1	80.8
Total number of harbour porpoise				6,856.4
Percentage of NS MU				1.98%

478. It should be noted that while the projects included within the in-combination assessment for disturbance from other OWFs constructing at the same time were done so based on the current knowledge of their possible construction or activity windows, and it is very unlikely that all activities would be taking place on the same day or in the same season, and therefore this likely represents an over-precautionary and worst case estimate of the marine mammals that could

be at risk of disturbance during the three year offshore construction period of North Falls.

Spatial assessment and seasonal average

479. There are no other OWFs that overlap with the SNS SAC winter area that may undergoing construction activities (other than piling) at the same time as North Falls.

480. Displacement of harbour porpoise would not exceed 20% of the winter seasonal component of the SNS SAC during the construction of other OWFs on the same day as piling at North Falls. Therefore, under these circumstances, there would be no significant disturbance and no adverse effect on the integrity of SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance from underwater noise due to construction activities (other than piling) for North Falls in-combination with other plans and projects.

In-combination impact 1c: Assessment of disturbance from other industries and activities

481. During the construction period for North Falls, there is the potential for disturbance to marine mammals associated with other potential noise sources, including:

- Geophysical surveys associated with other OWFs;
- Aggregate extraction and dredging;
- Oil and gas installation projects;
- Oil and gas seismic surveys;
- Subsea cable and pipelines;
- Other marine renewable projects (such as wave and tidal projects);
- Disposal sites; and
- UXO clearance.

482. For the installation of oil and gas infrastructure, marine renewable projects, and disposal sites, all potential projects have been screened out. Further information on the CEA screening (and these results) are provided in the PEIR Appendix 12.4 (Volume III).

Disturbance from geophysical surveys

483. It is currently not possible to estimate the number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls.

484. As outlined in the PEIR Appendix 12.4 (Volume III), OWF geophysical surveys using Sub-Bottom Profilers (SBPs) and Ultra-Short Base Line (USBL) systems have the potential to disturb marine mammals and have therefore been screened into the CEA, as a precautionary approach.

485. The potential disturbance range used in the in-combination assessment is based on the SNCB guidance for assessment for harbour porpoise.

486. Assessments for the RoC HRA for the SNS SAC (BEIS, 2020), modelled the potential for disturbance due to the use of a SBP, and results indicated that there is the potential for a possible behavioural response in harbour porpoise at up to 3.77km (44.65km^2) from the source. The current guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC et al., 2020) recommends the use of an EDR of 5km (78.54km^2) for geophysical surveys.

487. Following the current SNCB guidance for the assessment of geophysical surveys disturbance on harbour porpoise, it should be assessed as a moving source, rather than a stationary one (i.e. the distance at which a survey vessel could travel in one day, with a 5km buffer area). It is difficult to determine what the potential area of effect would be when taking into account it is a moving source (as it is difficult to predict how far a vessel may survey in a day).

488. Based on survey vessels travelling at a speed of 4.5 to 5 knots, up to 199km could be surveyed in one day. This however does not take into account the survey downtime for line changes, weather, or other technical reason. A review of seismic surveys within the UK indicated that surveys were being undertaken for approximately 52% of the time (BEIS, 2020). Taking this into account, up to 103.5km of surveys could be undertaken in one day, resulting in a potential disturbance area of 1,113.5km^2 with the 5km EDR buffer applied. This is highly precautionary as it is unlikely that the whole survey area would be within the SNS SAC.

489. It is currently not possible to estimate the location or number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. It is therefore assumed, as a worst case scenario, that there could potentially be up to two geophysical surveys in North Sea at any one time, during construction of North Falls.

490. As the location of the potential geophysical surveys is currently unknown, the following assessments are based on the density estimates, with a density estimate of 0.52/km^2 for harbour porpoise (based on the North Assessment Unit as presented in Hammond et al., 2021).

491. For up to two geophysical surveys undertaken at the same time as construction of North Falls, with no other in-combination activities, up to 2.1% of the NS MU population may be disturbed.

Table 6.38 Quantitative assessment for in-combination disturbance of marine mammals due to up to two geophysical surveys at OWFs

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)
North Falls	2.822	2,123.7	5,993.1
Two geophysical surveys	0.52	1,113.5 (per survey)	1,158.0
Total number of harbour porpoise			7,151.1
Percentage of NS MU			2.06%

Spatial assessment

492. As it is currently not possible to estimate the location or number of potential OWF geophysical surveys that could be undertaken at the same time as construction of North Falls, and due to the smaller area of the winter area of the SNS SAC in comparison to the North Sea area that has been assessed above, it is assumed, as a worst case scenario, that there could potentially be up to one geophysical survey in the winter area of the SNS SAC at any one time, during construction of North Falls.

493. If one geophysical survey was undertaken within the SNS SAC winter area (with an area of 1,113.5km^2), at the same time as piling at North Falls (maximum overlap area of 2,109.09km^2 for monopiles), the potential maximum area of disturbance could be 3,222.59km^2, which would be approximately 25.4% of the winter area. For pin piles, the in-combination disturbance area would be 1,820.35km^2 (14.3% of the winter SNS SAC area) (Table 6.39).

Table 6.39 Estimated overlaps with the SNS SAC winter area from one geophysical survey at OWFs on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area for monopiling at North Falls	Maximum overlap with seasonal area for pin piling at North Falls
North Falls	2,109.09 km^2	706.85 km^2
One geophysical survey	1,113.5 km^2	1,113.5 km^2
Total for winter area	3,222.59 km^2 (25.4% of the winter area)	1,820.35 km^2 (14.3% of the winter area)

494. The assessment indicates that, for monopiling at North Falls, more than 20% of the winter area could be affected, based on the maximum scenario. However, this does not take into account the potential for an overlap in disturbance areas, and the area for potential disturbance for geophysical surveys is considered to be highly precautionary.

495. In line with the conclusions of the RoC HRA (BEIS, 2020) a SIP will be developed for North Falls, which will set out the approach to deliver any Project-level mitigation or management measures, to ensure that the spatial threshold is not exceeded and there is no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

Seasonal average

496. The seasonal averages have been calculated by multiplying the maximum area on any one day by the proportion of days within the season on which geophysical surveys could occur at the same time as piling at North Falls (Table 6.40).

Table 6.40 Estimated seasonal averages with the SNS SAC winter area from geophysical surveys on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area	Number of piling days for in-combination effects with North Falls	In-combination assessment scenario
Winter area: A geophysical survey at the same time as monopiling at North Falls	3,222.59 km^2 (25.4% of the winter area)	74 days for piling at North Falls	10.3% of the winter season
Winter area: A geophysical survey at the same time as pin piling at North Falls	1,820.35 km^2 (14.3% of the winter area)	76 days for piling at North Falls	6.0% of the winter season

497. The assessment indicates that in the case of monopiles at North Falls, more than 10% of the winter area of the SNS SAC could be affected, due to geophysical surveys being undertaken on the same day as piling at North Falls. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North falls in-combination with geophysical surveys.

Disturbance from aggregate extraction and dredging

498. As a precautionary approach, a total of six aggregate extraction and dredging projects are included in the in-combination assessment for the potential in-combination disturbance.

499. As outlined in the BEIS (2020) RoC HRA for the SNS SAC, studies have indicated that harbour porpoise may be displaced by dredging operations within 600m of the activities (Diederichs et al., 2010). As a worst case assessment, a disturbance range of 600m for up to six operational aggregate projects at the same time as North Falls construction. A disturbance range of 600m would result in a potential disturbance area of 1.13km^2 for each project, or up to 6.8km^2 for all six aggregate projects.

500. For the potential for in-combination disturbance from aggregate and dredging projects undertaken at the same time as construction of North Falls, with no other in-combination activities, up to 1.7% of the NS MU population may be disturbed.

Table 6.41 Quantitative assessment for in-combination disturbance of harbour porpoise due to aggregate and dredging projects

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)
North Falls	2.822	2,123.7	5,993.1
Aggregate and dredging projects (1.13km^2 disturbance area per project)	0.52	6.78	3.5 (0.001%)

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)
Total number of harbour porpoise			5,998.6
Percentage of NS MU	1.7%		

<u>Spatial assessment and seasonal average</u>

501. None of the screened in aggregate projects are within (or within 600m of) the winter area of the SNS SAC. Therefore, an assessment against the spatial and seasonal thresholds has not been undertaken.

502. Therefore, under these circumstances there would be no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North Falls in-combination with aggregate extraction and dredging activities.

Disturbance from oil and gas seismic surveys

503. It is currently not possible to estimate the number of potential oil and gas seismic surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. Therefore, it has been assumed that at any one time, up to two seismic surveys could be taking place at the same time within the North Sea.

504. This assessment for the potential disturbance due to oil and gas seismic surveys is based on the potential impact area during seismic surveys, with an EDR of 12km (452.4km^2 per survey, or 904.8km^2 for two surveys). However, as stated above for geophysical surveys, under the JNCC *et al*., 2020 guidelines for assessing effects at harbour porpoise designated sites, seismic surveys should be considered as a moving source.

505. Following the same approach as undertaken for geophysical surveys above, and using 12km EDR, the total disturbance area for a seismic survey would be 2,936.4km^2 (or 5,872.8km^2 for two surveys).

506. For oil and gas seismic surveys, undertaken at the same time as construction of North Falls, up to 2.6% of the NS MU population may be disturbed (Table 6.42).

Table 6.42 Quantitative assessment for in-combination disturbance of harbour porpoise due to up to two oil and gas seismic surveys

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)
North Falls	2.822	2,123.7	5,993.1
Up to two seismic surveys	0.52	5,872.8	3,053.9 (0.88%)
Total number of harbour porpoise			9,047
Percentage of NS MU			2.6%

Spatial assessment

507. If one seismic survey was undertaken within the winter area (with an area of 2,936.4km^2), at the same time as monopiling at North Falls within the winter area, the potential area of disturbance could be 5,045.5km^2 which would be 39.7% of the winter area. For pin piles, the total area within one seismic survey would be 3,643.3km^2, or 29.7% of the winter SNS SAC area (Table 6.43).

Table 6.43 Estimated overlaps with the SNS SAC winter area from one seismic survey at OWFs on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area for monopiling at North Falls	Maximum overlap with seasonal area for pin piling at North Falls
North Falls	2,109.09 km^2	706.85 km^2
One seismic survey	2,936.4 km^2	2,936.4 km^2
Total for winter area	5,045.5 km^2 (39.7% of the winter area)	3,643.3 km^2 (29.7% of the winter area)

508. The assessment indicates that more than 20% of the winter area could be affected, based on the maximum overlapping scenario.

509. In line with the conclusions of the RoC HRA (BEIS, 2020) a SIP will be developed for North Falls, which will set out the approach to deliver any Project-level mitigation or management measures, to ensure that the spatial threshold is not exceeded and there is no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

510. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of in-combination disturbance effects from underwater noise during piling at North Falls and oil and gas seismic surveys.

Seasonal average

511. The seasonal averages have been calculated by multiplying the maximum area on any one day by the proportion of days within the season on which seismic surveys could occur on the same day as construction at North Falls (Table 6.44).

Table 6.44 Estimated seasonal averages with the SNS SAC summer and winter areas from seismic surveys on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area	Number of piling days for in-combination effects with north Falls	Estimated seasonal average
Winter area: One seismic survey at the same time as monopiling at North Falls	5,045.5 km^2 (39.7% of the winter area)	74 days for piling at North Falls	16.1% of the winter season

In-combination assessment scenario	Maximum overlap with seasonal area	Number of piling days for in-combination effects with north Falls	Estimated seasonal average
Winter area: One seismic survey at the same time as pin piling at North Falls	3,643.3 km^2 (29.7% of the winter area)	76 days for piling at North Falls	12.4% of the winter season

512. The assessment indicates that more than 10% of the winter areas of the SNS SAC could be affected, due to seismic surveys being undertaken on the same day as piling at North Falls. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North Falls in-combination with seismic surveys.

Disturbance from subsea cables and pipelines

513. Only one subsea pipeline has been screened into the in-combination assessment; Sea Link. This project is currently at scoping stage and therefore there is limited information available on potential effects and disturbance ranges for which to inform the in-combination assessment with North Falls.

514. The disturbance ranges that could be generated during the cabling works and vessels would be up to 4km (with a disturbance area of 50.3km^2), for harbour porpoise. This has been used to inform the assessments for subsea cabling and pipeline projects, as activities would be similar, in the absence of any additional information for the project screened in for assessment.

515. For disturbance from subsea cables and pipeline projects, and no other in-combination activities, up to 0.01% of the NS MU population may be disturbed (Table 6.45).

Table 6.45 Quantitative assessment for in-combination disturbance of marine mammals due to cable and pipeline projects

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed (% of reference population)
North Falls	2.822	2,123.7	5,993.1
Cable and pipeline projects	0.52	50.3	26.2 (0.01%)
Total number of harbour porpoise			6,019.3
Percentage of NS MU			1.74%

<u>Spatial assessments</u>

516. Sea Link is within the winter area of the SNS SAC. If Sea Link was constructed (with an area of up to 50.3km^2) at the same time as North Falls monopiling, the potential area of disturbance could be 2,159.39km^2, which would be approximately 17.01% of the winter area. If pin piling was undertaken at North

Falls at the same time as the Sea Link project, the potential for disturbance would cover an area of 757.15km^2 (or 5.96% of the SNS SAC winter area) (Table 6.46).

Table 6.46 Estimated overlaps with the SNS SAC winter area from sub-sea cable and pipeline projects on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area for monopiling at North Falls	Maximum overlap with seasonal area for pin piling at North Falls
North Falls	2,109.09 km^2	706.85 km^2
Cable and pipeline projects	50.3 km^2	50.3 km^2
Total for winter area	2,159.39 km^2 (17.01% of the winter area)	757.15 km^2 (5.96% of the winter area)

517. The displacement of harbour porpoise therefore would not exceed 20% of the winter seasonal component of the SNS SAC during subsea cable and pipeline projects on the same day as piling at North falls. Therefore, under these circumstances, there would be no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North Falls in-combination with subsea cables and pipelines.

Seasonal average

518. The seasonal averages have been calculated by multiplying the maximum area on any one day by the proportion of days within the season on which cable and pipeline projects (Sea Link) could occur at the same time as piling at North Falls (Table 6.47).

Table 6.47 Estimated Seasonal Averages with the SNS SAC Winter Area from Subsea Cable and Pipeline Projects on the Same Day as Single Piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area	Number of piling days for in-combination effects with North Falls	Estimated seasonal average
Winter area: Subsea cable and pipeline projects at the same time as monopiling at North Falls	2,159.39 km^2 (17.01% of the winter area)	74 days for piling at North Falls	6.92% of the winter season
Winter area: Subsea cable and pipeline projects at the same time as pin piling at North Falls	757.15km^2 (5.96% of the winter area)	76 days for piling at North Falls	2.49% of the winter season

519. The assessment indicates that on average less than 10% of the winter area of the SNS SAC could be affected, due to subsea cable and pipeline projects being undertaken on the same day as piling at North Falls. Therefore, under these circumstances there would be no significant disturbance and no adverse

effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North Falls in-combination with subsea cables and pipelines.

Disturbance from UXO clearance

520. As for piling, the potential risk of PTS in marine mammals from in-combination effects has been screened out from further consideration in the CEA; if there is the potential for any PTS, suitable mitigation would be put in place to reduce any risk to marine mammals. Therefore, the CEA only considers potential disturbance effects.

521. This assessment has been based on the potential for disturbance due to UXO clearance activities for other projects, cumulatively with the construction of North Falls.

522. It is currently not possible to estimate the number of potential UXO clearance events that could be undertaken at the same time as construction and potential piling activity at North Falls, and therefore, on a worst case basis, the potential for one high-order clearance and one low-order clearance has been assessed as having the potential to take place at the same time.

523. The potential effect area of 2,123.7km^2 per project, based on 26km EDR for UXO high order detonation, and 78.5km^2 for low-order detonation, following the current SNCB guidance for the assessment of impact to harbour porpoise in the SNS SAC.

524. However, as outlined in the BEIS (2020) RoC HRA, due to the nature of the sound arising from the detonation of UXO, i.e. each blast lasting for a very short duration, marine mammals, including harbour porpoise, are not predicted to be significantly displaced from an area, any changes in behaviour, if they occur, would be an instantaneous response and short-term. Existing guidance suggests that disturbance behaviour is not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC, 2010a).

525. Mitigation measures required for UXO clearance include the use of low-order clearance techniques, which could include a small donor charge, rather than full high-order detonation which is only used as a last resort. It is therefore highly unlikely that more than one UXO high-order detonation would occur at exactly the same time or on the same day as another UXO high-order detonation, even if they had overlapping UXO clearance operation durations. The CEA is therefore based on potential for disturbance from one UXO high-order detonation without mitigation (worst case), as well as one low-order clearance event.

Table 6.48 Quantitative assessment for in-combination disturbance of harbour porpoise due to UXO clearance

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	2.822	2,123.7	5,993.1
One high-order UXO detonation	0.52	2,123.7	1,104.3

Potential in-combination effect	Marine mammal density (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
One low-order UXO detonation	0.52	78.5	40.8
Total number of harbour porpoise (% of reference population)			7,138.1 (2.06%)

Spatial assessment

526. If one high-order UXO detonation was undertaken within the winter area (with an area of 2,123.7km^2), at the same time as monopiling at North Falls, the potential average area of disturbance could be 4,232.8km^2 which would be approximately 33.3% of the winter area (or up to 2,830.6km^2 (22.3% of the SNS SAC winter area for a pin piling at North Falls with high-order UXO clearance)).

527. For one low-order detonation with monopiling at North Falls, the potential average area of disturbance could be 2,187.59km^2 which would be approximately 17.2% of the winter area (or up to 785.4km^2 (6.2% of the SNS SAC winter area for a pin piling at North Falls with low-order UXO clearance)).

Table 6.49 Estimated overlaps with the SNS SAC winter area from UXO clearance on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area for monopiling at North Falls	Maximum overlap with seasonal area for pin piling at North Falls
North Falls	2,109.09 km^2	706.85 km^2
One high-order UXO detonation	2,123.7 km^2	2,123.7 km^2
Total for winter area	4,232.8 km^2 (33.3% of the winter area)	2,830.6 km^2 (22.3% of the winter area)
One low-order UXO detonation	78.5 km^2	78.5 km^2
Total for winter area	2,187.59 km^2 (17.2% of the winter area)	785.4 km^2 (6.2% of the winter area)

528. The displacement of harbour porpoise therefore would not exceed 20% of the winter seasonal component of the SNS SAC on any given day during single low-order UXO detonations in the winter areas at the same time as piling at North Falls, however, the 20% threshold would be exceeded for any high-order UXO clearance on the same day (within the winter season) as piling at North Falls.

529. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, there would be no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North Falls in-combination with UXO clearance activities at other OWF projects.

Seasonal average

530. The seasonal averages have been calculated by multiplying the average area on any one day by the proportion of days within the season on which UXO clearance could occur at the same time as piling at North Falls (Table 6.50).

Table 6.50 Estimated seasonal averages with the SNS SAC summer and winter areas from uxo clearance on the same day as single piling at North Falls

In-combination assessment scenario	Maximum overlap with seasonal area	Number of piling days for in-combination effects with North Falls	Estimated seasonal average
One high-order UXO clearance			
Winter area: One UXO clearance at the same time as monopiling at North Falls	4,232.8km^2 (33.3% of the winter area)	74 days	13.5% of the winter season
Winter area: One UXO clearance at the same time as pin piling at North Falls	2,830.6km^2 (22.3% of the winter area)	76 days	9.3% of the winter season
One low-order UXO clearance			
Winter area: One UXO clearance at the same time as monopiling at North Falls	2,187.59km^2 (17.2% of the winter area)	74 days	7.0% of the winter season
Winter area: One UXO clearance at the same time as pin piling at North Falls	785.4km^2 (6.2% of the winter area)	76 days	2.6% of the winter season

531. The assessment indicates that on average less than 10% of the winter areas of the SNS SAC could be affected, if there was one high-order UXO detonation at the same time as pin piling at North Falls, or for any low-order clearance with piling at North Falls. However, the 10% seasonal threshold could be exceeded for monopiling at North Falls with high-order UXO clearance.

532. With the use of appropriate mitigation and management measures defined through the SIP process, and managed by the MMO, there would be no significant disturbance and no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of disturbance due to underwater noise (other than piling) from North Falls in-combination with UXO clearance activities at other OWF projects.

In-combination effect 1: overall in-combination disturbance effects from all noise sources

533. Each of the above described noise sources with the potential for disturbance on harbour porpoise are quantitively assessed together in Table 6.51.

534. For harbour porpoise, for noisy activities with the potential for in-combination disturbance effects together with piling at North Falls, up to 7.0% of the population at risk of disturbance.

535. Based on the worst-case scenarios and very precautionary approach, there is the potential for up to 82.60% of the winter area to be disturbed on any one day, and up to 33.6% to be disturbed over the season (Table 6.51). It should be noted that the largest impacts estimated in the in-combination assessment are due to possible effects from seismic surveys (which are unrelated to North Falls or any OWF) and UXO clearance. Behavioural effects from UXO clearance, if they occur, would be an instantaneous response and short-term. Guidance suggests that disturbance behaviour is not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC, 2010) and therefore could be excluded from the total.

Table 6.51 Quantitative assessment for all noisy activities with the potential for in-combination disturbance effects for harbour porpoise

Impact	Number of individuals	Spatial overlap	Seasonal overlap (assuming overlapping with 74 days of monopiling at North Falls)
Worst case disturbance at North Falls (single monopiling event) (Table 6.15;Table 6.16; Table 6.17)	5,993.1	2,109.09km^2 (16.61%)	6.75%
Piling at other OWFs (Table 6.34; Table 6.35; Table 6.36)	12,047.8	2,154.2km^2 (16.97%)	6.90%
Construction activities at other OWFs (Table 6.37)	863.3	0km^2	0%
Up to two geophysical surveys (Table 6.38; Table 6.40)	1,158.0	1,113.5km^2 (8.77%)	3.57%
Aggregates and dredging (Table 6.41)	3.5	0km^2	0%
Up to two oil and gas seismic surveys (Table 6.42; Table 6.44)	3,053.9	2,936.4km^2 (23.13%)	9.40%
Subsea cables and pipelines (Table 6.45; Table 6.47)	26.2	50.3km^2 (0.40%)	0.16%
High order UXO clearance (as a worst-case) (Table 6.48)	1,104.3	2,123.7km^2 (16.73%)	6.80%
Total for all activities and projects (Total without North Falls)	24,250.1 (7.0% of the NS MU) 18,257.0 (5.3% of the NS MU)	10,487.2km^2 (82.60% of the SNS SAC winter area) 8,378.1km^2 (65.99% of the SNS SAC winter area)	33.58% 26.83%

536. It should be noted that while the projects included within the in-combination assessment for disturbance from other activities and industries were done so based on the current knowledge of their possible construction or activity

windows, it is very unlikely that all activities would be taking place on the same day or in the same season, and therefore this likely represents an over-precautionary and worst case estimate of the harbour porpoise that could be at risk of disturbance during the three year offshore construction period of North Falls.

537. This in-combination assessment will be refined and updated prior to DCO submission, to take account of the latest information on project programmes and any detail on project-level mitigation commitments or marine licence conditions from the in-combination projects. The final assessment will also take account of the potential for overlaps in the disturbance areas of all activities, and whether they are likely to take place on the same day or within the same season to refine the assessments. The assessment will also take into account the number of days of each activity included. It is expected that taking these points into consideration would reduce the overlaps.

538. Mitigation measures are under review and will be presented in the final RIAA for the DCO application submission. NFOW will seek to ensure that there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise as a result of North Falls in-combination with other plans and projects.

6.2.3.4.2 In-combination impact 2: Barrier effects

539. For the assessment of the potential for barrier effects due to underwater noise from projects undergoing construction, the effect to marine mammal species would be as per the assessments provided in Table 6.51, for in-combination disturbance effects due to all noisy activities.

540. It is important to note that the OWFs and other noise sources included in the in-combination assessment are spread over the wider area of the North Sea. Taking into account the locations of the OWFs and other noise sources from North Falls, the maximum underwater effect ranges for disturbance at other projects would not overlap with the maximum underwater effect ranges for disturbance at North Falls during piling and construction. Therefore, there is no potential for underwater noise from North Falls, other OWFs and noise sources to result in a barrier of movement to marine mammals.

541. The potential for a barrier effect due to underwater noise during operation was assessed as having no effect, and therefore has not been considered within this in-combination assessment.

542. Therefore, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.4.3 In-combination impact 3: Increased collision risk with vessels

543. The increased collision risk even using a very precautionary approach, has predicted there would be a low number of individuals at risk (with 4.76 harbour porpoise at risk during the operational phase being the highest number at risk).

544. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore there would be no increased collision risk as the increase in the number of OWF vessels would be relatively small compared to the baseline levels of vessel movements in the Harwich or Lowestoft areas (indicative areas).

545. Once on-site, OWF vessels would be stationary or slow moving, as they undertake the activity they are associated with. Therefore, the risk of any increased collision risk for harbour porpoise would be negligible, if any.

546. Vessels associated with aggregate extraction and dredging are large and typically slow moving, using established transit routes to and from ports. Therefore, the potential increased collision risk with vessels is considered to be extremely low or negligible. Therefore, increased collision risk from aggregate extraction and dredging has been screened out from further consideration in the in-combination assessment.

547. Good practice measures, as implemented for North Falls, would ensure any risk of vessels colliding with marine mammals is avoided.

548. Therefore, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.2.3.4.4 In-combination impact 4: Changes in prey resource

549. For any potential changes to prey resources, it has been assumed that any potential effects on harbour porpoise prey species from underwater noise, including piling, would be the same or less than those for harbour porpoise. Therefore, there would be no additional in-combination effects other than those assessed for harbour porpoise, i.e. if prey are disturbed from an area as a result of underwater noise, harbour porpoise will be disturbed from the same or greater area. As a result any changes to prey resources would not affect harbour porpoise as they would already be disturbed from the area.

550. Any effects to prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat for prey species in the surrounding area.

551. Taking into account the assessment for North Falls alone (Section 6.2.3.2.6), and assuming similar effects for other projects and activities, along with the range of prey species taken by harbour porpoise and the extent of their foraging ranges, there would be no potential for in-combination effect on harbour porpoise populations as a result of changes to prey resources.

552. Therefore, there would be no adverse effect on the integrity of the SNS SAC in relation to the conservation objectives for harbour porpoise.

6.3 Humber Estuary SAC and Ramsar

6.3.1 Site overview

553. The Humber is the second largest coastal plain estuary in the UK, and the largest on the east coast of Britain. Grey seal are present as a qualifying feature of the Humber Estuary SAC (Natural England, 2009).

554. The Humber Estuary SAC is located, at closest point, 207km from North Falls. Therefore, there is no potential for direct effect on the SAC as a result of the construction, operation, maintenance or decommissioning of North Falls. However, due to the foraging range of grey seal and the movement of grey seal

along the east coast of England, there is the potential for effects on foraging grey seal from the Humber Estuary SAC in the vicinity of North Falls.

555. Note that the SAC is largely coincident[8] with the Humber Estuary Ramsar site for which grey seal are listed under Ramsar Criterion 3. This criterion states "*A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.*"

6.3.1.1 Qualifying Feature

6.3.1.1.1 Grey seal

556. There is a considerable amount of movement of grey seals among different areas and regional subunits of the North Sea, and there is no evidence to suggest that grey seals on the North Sea coasts of Denmark, Germany, the Netherlands, or France are independent from those in the UK (SCOS, 2021).

557. Compared with other times of the year, grey seal in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season, in eastern England, pupping occurs mainly between early November and mid-December (SCOS, 2021).

558. North Falls is located approximately 22.5km offshore (at the closest point to shore).

559. The Donna Nook haul-out site is within the Humber Estuary SAC and represents the current best grey seal population estimate of the SAC. In August 2021 there were 3,897 grey seal counted at Donna Nook (SCOS, 2022).

560. A relatively low number of grey seal were recorded during the site-specific aerial surveys, with a total of 13 individuals recorded during the 24 surveys, however, in addition a total of 23 unidentified seal species were recorded, as well as 17 seal / small cetacean species, a proportion of which are expected to be grey seal.

561. Throughout the surveys the numbers of grey seal, or individuals that could be grey seal (i.e. seal species and seal / small cetacean species) were relatively similar year-round, with no clear change seasonally. Due to the low number of grey seal sightings, absolute density and abundance estimates were not possible to derive from the site-specific surveys.

562. Carter et al. (2022) produced habitat-based predictions of at-sea distribution for grey seals in the British Isles. The resultant density of seals at-sea maps show the relative density of seals in each 5km by 5km grid cell. As well as the total grey seals at-sea densities, Carter *et al*. (2022) provide SAC specific densities. These SAC specific densities provide the relative density of grey seal that are associated with each SAC. These SAC specific density estimates have been used to calculate the density of grey seal, associated with the Humber Estuary SAC, present within the North Falls project areas (Figure 6.4). This effectively

[8] There is a small section of coast at Easington which is included in the Ramsar site which is not included within the SAC.

apportions the potential for effect to only those seals that are affected that are associated with the SAC itself.

563. The mean at sea relative density estimates of grey seal for North Falls, and all offshore export cable areas calculated from Carter et al. (2022) are:

- 0.006 individuals per km^2 for the south array area;
- 0.018 individuals per km^2 for north array area;
- 0.009 individuals per km^2 for the total array areas; and
- 0.012 individuals per km^2 for the total offshore cable corridor.

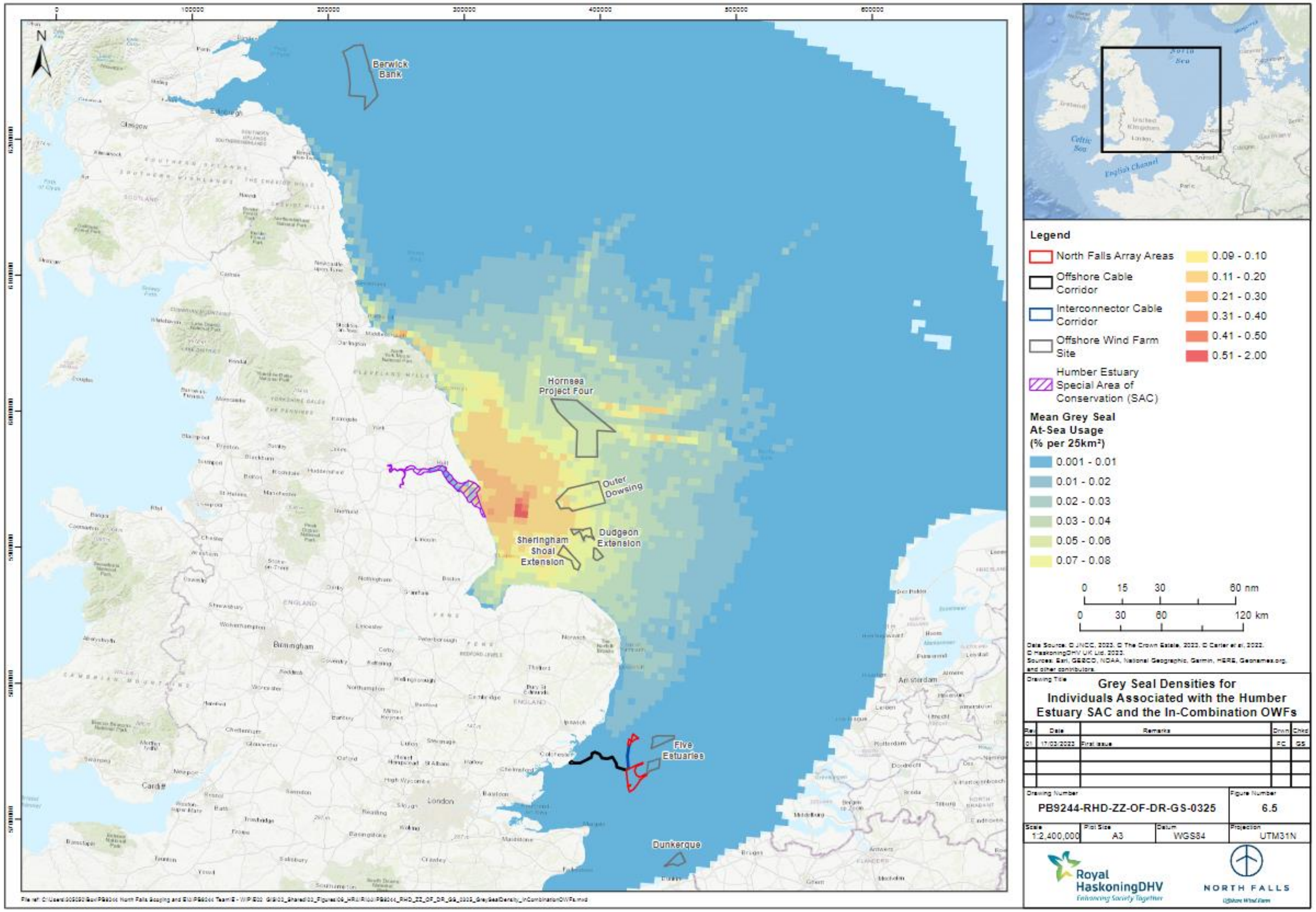

Figure 6.4 Grey seal at-sea mean densities for those individuals associated with the Humber Estuary SAC

564. The assessments are based on mean relative density estimates for the Humber Estuary SAC from Carter *et al.* (2022) as a worst-case. The corrected SAC grey seal count was used to generate absolute densities from the relative density data of Carter *et al*. (2022). This at-sea population number is 13,351[9], based on the total population of grey seal at the Humber Estuary SAC (provided in Table 6.52), and calculating against a correction factor of 0.8616 (Russell et al., 2015; Carter *et al.,* 2020) to take account of those individuals at sea only.

565. The Humber Estuary SAC population has been corrected to take account of the number of seals not available to count during the surveys. Approximately 0.2515 grey seals are available to count within the August surveys (i.e. are hauled-out), and therefore this has been used as a correction factor, to derive the grey seal SAC population (Table 6.52).

Table 6.52 Grey seal counts and population estimates

Population area	Grey seal haul-out count	Source of haul-out count data	Correction factor for seals not available to count	Grey seal SAC population
Humber Estuary SAC population estimate	3,897	SCOS 2020	0.2515	15,495

566. Assessments are undertaken against the SAC population estimate of 15,495 seals, for both the project alone and in-combination.

6.3.2 Conservation objectives

567. The Conservation Objectives (Natural England, 2018b) are “To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species
- The structure and function (including typical species) of qualifying natural habitats
- The structure and function of the habitats of qualifying species
- The supporting processes on which qualifying natural habitats and habitats of qualifying species rely
- The populations of qualifying species, and,
- The distribution of qualifying species within the site.”

568. For grey seal within the Humber Estuary SAC, the specific targets are to;

- Maintain the population size within the site;
- Maintain the reproductive and recruitment capability of the species;

[9] Note this is not the total SAC population estimate, as accounts for only those seals that are at-sea and not those that could be hauled-out

- Maintain the presence and spatial distribution of the species and their ability to undertake key life stage and behaviours;
- Maintain connectivity of the habitat within sites and the wider environment to allow movement of migratory species;
- Restrict the introduction and spread of non-native species and pathogens, and their impacts;
- Maintain the extent and spatial distribution of the following supporting habitats; foraging and haulout sites;
- Maintain the cover / abundance of preferred food items required by the species;
- Maintain the natural physio-chemical properties of the water;
- Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement is not significantly altered or constrained;
- Restrict aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels;
- Maintain water quality to mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels; and
- Maintain natural levels of turbidity (e.g. suspended concentrations of sediment, plankton and other material) in areas where this species is, or could be present.

569. Note that with regard to the Ramsar designation, Natural England advice states that for Ramsar sites, a decision has been made by Defra and Natural England not to produce Conservation Advice packages. As the provisions on the Habitats Regulations relating to HRA extend to Ramsar sites, Natural England considers the Conservation Advice packages for the overlapping European Marine Site designations to be, in most cases, sufficient to support the management of the Ramsar interests. Therefore, the conservation objectives listed above cover both the SAC and Ramsar requirements.

6.3.3 Shadow appropriate assessment

570. For the assessments, the potential for any effects is considered in relation to the Humber Estuary SAC Conservation Objectives for grey seal as outlined in Table 6.53.

Table 6.53 Potential effects of North Falls in relation to the Conservation Objectives of the Humber Estuary SAC for Grey Seal

Conservation Objective for grey seal	Potential effect
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	No potential adverse effect There will be no significant change to the extent and distribution of the habitats of qualifying species in the SAC.

Conservation Objective for grey seal	Potential effect
The structure and function (including typical species) of qualifying natural habitats.	No potential adverse effect There will be no significant change to the structure and function (including typical species) of qualifying natural habitats.
The structure and function of the habitats of qualifying species.	No potential adverse effect There will be no significant change to the structure and function) of the habitats of the qualifying species.
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	No potential adverse effect There will be no significant change to the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.
The populations of qualifying species.	Increased collision risk with vessels will be considered further.
The distribution of qualifying species within the site.	No potential adverse effect There will be no significant change to the distribution of qualifying species within the site. However, significant disturbance and displacement as a result of increased underwater noise levels have the potential to have an effect on the seals foraging at sea and will be considered further.

6.3.3.1 Potential effects during construction

571. Potential effects during construction may arise through disturbance from activities during the installation of offshore infrastructure. Underwater noise during piling, as well as disturbance associated with underwater noise from other construction activities and the presence of vessels offshore, are considered. Potential displacement from important habitat areas and impacts on prey species are also considered.

572. The potential effects during construction assessed for marine mammals are:

- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during piling, and due to ADD activation prior to piling;
  - Permanent auditory injury (PTS) due to impact piling.
  - Disturbance due to impact piling.
  - Disturbance due to ADD activation prior to piling.
- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during other construction activities, including seabed preparations, rock placement and cable installation;
  - Permanent auditory injury (PTS) due to other construction activities.
  - Disturbance due to other construction activities.
- Impacts resulting from the deployment of construction vessels:
  - Underwater noise and disturbance from construction vessels;
    - Permanent auditory injury (PTS) due to construction vessels.
    - Disturbance due to construction vessels.
  - Vessel interaction (collision risk).

- Barrier effects as a result of underwater noise;
- Changes to water quality; and
- Changes to prey resource.

573. The potential for disturbance at seal haul-out sites has not been assessed for the Humber Estuary SAC. Due to the distance between North Falls and the SAC, there is no potential for an effect to the haul-out sites within the site.

6.3.3.1.1 Impact 1: Effects of underwater noise associated with piling

574. A range of foundation options are being considered for North Falls, including monopiles, jackets (with pin piles), suction buckets for both monopiles and jacket pin piles, and gravity-based for both monopiles and jacket pin piles. Of these, monopiles and jackets (with pin piles) may require piling. As a worst case scenario for underwater noise, it has been assumed that all foundations could be piled, although drive-drill-drive installation may be used.

575. Impact piling is a source of high-level underwater noise, which can cause both physiological (e.g. lethal, physical injury and auditory injury) and behavioural (e.g. disturbance and masking of communication) effects on marine mammals.

576. Should a seal be very close to the source, the high peak pressure sound levels have the potential to cause death or physical injury, with any severe injury potentially leading to death, if no adequate mitigation is in place. High exposure levels from underwater noise sources can cause auditory injury or hearing impairment, taking the form of a permanent loss of hearing sensitivity (PTS).

Impact 1a: Permanent auditory injury (PTS) due to impact piling

577. Any PTS would be permanent, and marine mammals within the potential impact area are considered to have very limited capacity to avoid such effects, and unable to recover from the effects.

578. PTS can occur instantaneously from acute exposure to high noise levels, such as single strike (SPLpeak) of the maximum hammer energy applied during piling. PTS can also occur as a result of prolonged exposure to increased noise levels, such as during the duration of pile installation (SELcum).

579. The underwater noise modelling was based on the worst-case scenarios for monopiles and pin-piles as shown in Section 6.2.3.1.1.

PTS from a single strike

580. The underwater noise modelling results for the predicted effect ranges and areas for PTS from a single strike of the maximum hammer energy for the worst case location for grey seal is shown in Table 6.54 (see PEIR Appendix 12.2, Volume III for details).

Table 6.54 The predicted effect ranges for PTS for grey seals, at the worst case modelling location, for the maximum hammer energies of both monopiles and pin piles

Marine mammal species	Potential effect ranges (and areas) for PTS at the maximum hammer energy	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Grey seal	60m (0.01km^2)	<50m (<0.01km^2)

581. An assessment of the maximum number of individuals that could be at risk of instantaneous PTS, due to a single strike at the maximum hammer energy, for both monopiles and jacket pin piles, is presented in Table 6.55, based on the effect areas as presented in Table 6.54.

Table 6.55 Assessment of the potential for instantaneous PTS due to a single strike of the maximum hammer energy for a monopile and jacket pin pile for grey seal

Piling scenario	Assessment of effect
PTS due to a single strike of a monopile at maximum hammer energy (SPL_{peak})	0.0002 grey seal associated with the Humber Estuary SAC (0.000001% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.
PTS due to a single strike of a jacket pin pile at maximum hammer energy (SPL_{peak})	0.0002 grey seal associated with the Humber Estuary SAC (0.000001% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.

PTS from cumulative exposure

582. Table 6.56 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS due to the cumulative exposure of monopiles and jacket pin piles at the worst case location.

583. The potential cumulative effect ranges are the same for either one or two sequential monopiles, or for one or four sequential jacket pin piles.

584. It is important to note that assessment for PTS from cumulative exposure is highly precautionary. There is a lot of variation in the potential effect ranges for SEL_{cum} at each location and between locations.

Table 6.56 The predicted effect ranges for PTS in grey seals, at the worst case modelling location, for the cumulative exposure of both monopiles and pin piles

Marine mammal species	Potential effect ranges (and areas) for PTS due to cumulative exposure	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Single pile installation in a 24 hour period	One monopile	One jacket pin pile
Grey seal	100m (0.10km^2)	<100m (<0.10km^2)
Multiple sequential pile installations in a 24 hour period	Two sequential monopiles	Four sequential jacket pin piles
Grey seal	100m (0.10km^2)	<100m (<0.10km^2)

585. An assessment of the maximum number of individuals that could be at risk of cumulative PTS, for both sequential monopiles and jacket pin piles, is presented in Table 6.57.

Table 6.57 Assessment of the potential for PTS due to the cumulative exposure of sequential monopiles or jacket pin piles in a 24 hour period

Piling scenario	Assessment of effect
PTS due to the cumulative exposure of two sequential monopiles in a 24 hour period (SEL_{cum})	0.002 grey seal associated with the Humber Estuary SAC (0.00001% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.
PTS due to the cumulative exposure of four sequential jacket pin piles in a 24 hour period (SEL_{cum})	0.002 grey seal associated with the Humber Estuary SAC (0.00001% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.

PTS from cumulative exposure from multiple piling locations

586. The simultaneous piling scenario assumes that animals are within potential effect ranges for a much longer period (i.e. they would be travelling from one pile location to another which piling is ongoing), and therefore cumulative effect ranges are much larger than for the cumulative exposure ranges of one pile at a time.

587. The potential effect ranges are not possible to model under this scenario, as there are two starting points for receptors, and it is not possible to determine the potential range at which they need to be in order to not be at risk of effect. Therefore, the following assessment is based on the potential areas of effect only.

588. Where the potential effect areas are not large enough to interact with each other (i.e. they do not meet), the results for the respective locations and scenarios are used (the results of the modelling for the South and North locations are used to inform the assessment, to align with the modelling locations used for the simultaneous modelling.

589. Table 6.58 presents the underwater noise modelling results for the predicted effect ranges and areas for PTS due to the cumulative exposure of simultaneous monopiles and jacket pin piles at the North and South modelling locations. These locations were chosen as they have the potential for the largest 'spread' in terms of underwater noise propagation (as they are the two furthest apart locations). The modelling includes two monopiles being installed sequentially at each location at the same time, and four jacket pin piles being installed sequentially at each location at the same time.

Table 6.58 The predicted effect ranges for PTS grey seals at the North and South modelling locations, for the cumulative exposure of multiple monopiles and pin pile installations at the same time

Marine mammal species	Potential effect areas for PTS due to cumulative exposure of simultaneous pile installations	
	Monopile (6,000kJ)	Jacket pin pile (3,000kJ)
Multiple sequential pile installations in a 24 hour period (for the East and South modelling locations together)	Two sequential monopiles at the North location and two sequential monopile at the South location	Four sequential jacket pin piles at the North location and four sequential jacket pin piles at the South location
Grey seal	North = <0.1km^2 South = <0.1km^2 Total together = <0.2km^2	North = <0.1km^2 South = <0.1km^2 Total together = <0.2km^2
Multiple simultaneous pile installations in a 24 hour period (one at the North and one at the South modelling location)	Multiple simultaneous monopiles (two sequential monopiles at each location, at the same time)	Multiple simultaneous jacket pin piles (four sequential jacket pin piles at each location, at the same time)
Grey seal	No interaction	No interaction

590. An assessment of the maximum number of individuals that could be at risk of cumulative PTS, for simultaneous monopiles and jacket pin piles is presented in Table 6.59.

Table 6.59 Assessment of the potential for PTS due to the cumulative exposure of simultaneous monopiles or jacket pin piles at the same time

Piling scenario	Assessment of effect
PTS due to the cumulative exposure of simultaneous monopile installations (SEL_{cum})	0.004 grey seal associated with the Humber Estuary SAC (0.00002% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.
PTS due to the cumulative exposure of simultaneous jacket pin pile installations (SEL_{cum})	0.004 grey seal associated with the Humber Estuary SAC (0.00002% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.

Summary for Impact 1a

591. The assessment for permanent changes in hearing sensitivity (PTS) from a single strike of the maximum hammer energy for monopiles (without any mitigation) has been assessed as having no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

592. For the potential PTS from cumulative exposure for sequential monopile installations (without mitigation), there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

593. For the potential PTS from cumulative exposure for simultaneous monopile installations (without mitigation), there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

Impact 1b: Disturbance effects due to impact piling

594. The range of possible behavioural reactions that may occur as a result of exposure to noise include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour, temporary or permanent habitat abandonment and, in severe cases, panic, or stranding, sometimes resulting in injury or death (Southall et al., 2007).

595. There are currently no agreed thresholds or criteria for the behavioural response and disturbance of marine mammals, therefore it is not possible to conduct underwater noise modelling to predict impact ranges.

596. Disturbance from construction activities (including piling) may have behavioural consequences on marine mammals in the study area, including reduced time spent foraging at sea as animals move away from sources of noise, displacement from vessels, etc. Repeated disruptions can have cumulative negative effects on the bioenergetic budget of marine species, with the potential for long-term effects on survival and reproductive rates (Christiansen et al., 2013).

597. Hastie et al. (2021) studied the change in foraging behaviour of grey seal when exposed to underwater noise. A high density and low density area of prey was present within an experimental pool, and speakers were located at each prey patch. During the control periods, seals would forage mainly at the high-density patch, but also at the low-density patch for a smaller proportion of time. When

the seals were exposed to noise at the low density patch, there was a reduction in foraging of 16-28%, however, when seals were exposed to noise at the high density prey patch, there was no change in foraging in comparison to control periods (Hastie et al., 2021). This indicates that seals would choose to remain at a noisy environment, if there were good prey resources at the same location (Hastie et al., 2021).

598. Russell et al (2016) have shown that harbour seal are present in significantly reduced number up to a distance of 25km during piling (or a disturbance area of 1,963.5km^2). This range has been used to determine the number of grey seal that may be disturbed during piling at North Falls (Table 6.60).

Table 6.60 Assessment of the potential for disturbance to grey seal based on a disturbance range of 25km for both monopiles and jacket pin piles

Piling scenario	Assessment of effect
For a single piling event	35.3 grey seal associated with the Humber Estuary SAC (0.2% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.
For two simultaneous piling events*	70.7 grey seal associated with the Humber Estuary SAC (0.5% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.

** not taking into account any overlap between disturbance areas between the two locations*

599. For disturbance based on the known effect ranges for marine mammals, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

Impact 1c: Disturbance effects due to ADD activation

600. The assessments of the potential disturbance during any ADD activation is indicative only, as the final requirements for mitigation in the MMMP will be determined prior to construction.

601. Mitigation to reduce the risk of PTS could include activation of ADDs prior to the soft-start commencing. The period of time that an ADD is required to be activated for is dependent on the potential PTS ranges for each species, and their known swim speeds, as used within the underwater noise modelling.

602. During 10 minutes of ADD activation grey seal would move at least 0.9km from the ADD location (based on a precautionary marine mammal swimming speed of 1.5m/s; Otani et al., 2000), resulting in a potential disturbance area of 2.55km^2. This is further than the instantaneous PTS range for monopiles predicted for grey seal.

603. For 10 minutes of ADD activation, up to 0.046 grey seal associated with The Humber Estuary SAC (0.0003% of the SAC population) could be disturbed based on the array area density estimate of 0.018/km^2.

604. The ADD activation would ensure marine mammals are beyond the maximum impact range for instantaneous PTS due to a single strike of the maximum hammer energy for both monopiles and jacket pin piles. ADD activation prior to the soft-start would also reduce the number of marine mammals at risk of PTS from cumulative exposure.

605. There would be no adverse effect for disturbance from ADD activation based on the known effect ranges for marine mammals on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.1.2 Impact 2: Effects from underwater noise associated with other construction activities

606. Potential sources of underwater noise during construction activities, other than piling, include seabed preparation, dredging, rock placement, trenching and cable installation.

607. Dredging/cable installation activities have the potential to generate underwater noise at sound levels and frequencies for sufficient durations to disturb marine mammals. Reviews of published sources of underwater noise during dredging activity (e.g. Thomsen et al., 2006; Theobald et al., 2011; Todd et al., 2014), indicate that the sound levels that marine mammals may be exposed to during dredging activities are typically below permanent auditory injury thresholds (PTS) exposure criteria (as defined in Southall et al., 2019). Therefore, the potential risk of any auditory injury in marine mammals as a result of dredging activity is highly unlikely.

608. Underwater noise as a result of dredging activity/cable installation, also has the potential to disturb marine mammals (Pirotta et al., 2013). Therefore, there is the potential for short, perhaps medium-term behavioural reactions and disturbance to marine mammals in the area during dredging / cable installation activity. Marine mammals may exhibit varying behavioural reactions intensities as a result of exposure to noise (Southall et al., 2007).

609. The noise levels produced by dredging activity/cable installation, could overlap with the hearing sensitives and communication frequencies used by marine mammals (Todd et al., 2014), and therefore have the potential to impact marine mammals present in the area.

610. The potential for disturbance that could result from underwater noise during other construction activities, including cable laying and protection would be temporary in nature, not consistent throughout the offshore construction period, and would be limited to only part of the overall construction period and area at any one time.

611. The duration for the offshore construction period, including piling and offshore export cable installation, is approximately three years. However, construction activities would not be underway constantly throughout this period. Further details on the construction schedule are provided in Chapter 5 Project Description (Volume I).

612. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during noisy activities (PEIR Appendix 12.2, Volume III**)** and determine the potential effects on marine mammals.

Impact 2a Permanent auditory injury (PTS) due to other construction activities

613. Underwater noise modelling for the predicted effect ranges and areas for PTS from the cumulative exposure of other construction activities has been undertaken. For SEL_{cum} calculations, the duration of the noise is also considered, with all sources operating for a worst case of 12-hours in a day.

The predicted effect ranges for cumulative PTS for other construction activities on grey seals indicated <100m (0.031km^2).

614. The results of the underwater noise modelling do not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

615. The results of the underwater noise modelling indicate that grey seals would have to be <100m (precautionary maximum range) from the continuous noise source for 12 hours, to be exposed to noise levels that could induce PTS. It should be noted that the predicted impact ranges are the distances which represent the 'onset' stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

616. For PTS from a single activity, 0.0006 grey seal associated with the Humber Estuary SAC (0.000004% of the Humber Estuary SAC population) could be at risk, based on the northern array area density of 0.018/km^2, or 0.0004 grey seal associated with the Humber Estuary SAC (0.000002% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

617. There is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore export cable or interconnector corridors, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been undertaken. The predicted effect area of PTS for all four other construction activities taking place at the same time for grey seal is 0.126km^2.

618. For PTS from up to four other construction activities taking place at the same time, 0.002 grey seal associated with the Humber Estuary SAC (0.00001% of the Humber Estuary SAC population) could be at risk, based on the northern array area density of 0.018/km^2, or 0.002 grey seal associated with the Humber Estuary SAC (0.00001% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

Impact 2b: Disturbance effects due to other construction activities

619. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

620. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance impact on marine mammals.

621. There is limited data on the potential for a behavioural response or disturbance from other construction activities. A review of various studies was used to determine the maximum potential disturbance range for other construction activities and vessels. During the construction of two Scottish OWFs (Beatrice OWF and Moray East OWF), Benhemma-Le Gall et al. (2021), reported a 4km (50.3km^2) reduction in harbour porpoise presence and this has been used as

the disturbance range for other construction activities, including vessels. As harbour porpoise are the most sensitive marine mammal species, this 4km potential disturbance range has been used for grey seal as a worst case, due to the absence of any other data to inform an assessment.

622. An assessment of the maximum number of individuals that could be at risk of disturbance due to other construction activities based on the 4km potential disturbance range is presented in Table 6.61. This is a precautionary approach as it is unlikely that grey seal would react in the same manner as harbour porpoise to the other construction activities that are expected to be taking place in the offshore project area.

Table 6.61 Assessment of the potential for disturbance due to other construction activities, including cable laying, suction dredging, cable trenching, and rock placement, for one activity taking place at any one time

Marine mammal species	Assessment of effect
Grey seal	0.9 grey seal associated with the Humber Estuary SAC (0.006% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2; or 0.6 grey seal associated with the Humber Estuary SAC (0.004% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

623. As noted above, there is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore export cable or interconnector corridors, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been undertaken.

624. Based on a 4km potential disturbance range, and up to four other construction activities taking place at the same time, there is the potential for a simultaneous disturbance effect area of 201.06km^2 for all marine mammal species. As noted above, this assumes that the disturbance would only affect the area around the vessel at the time of the activity taking place, and that marine mammals would return to the disturbed area once the activity had either completed or transited to a new location.

625. An assessment of the maximum number of individuals that could be at risk of disturbance, due to all other construction activities undertaken at the same time is presented in Table 6.62.

Table 6.62 Assessment of the potential for disturbance due to all other construction activities taking place at the same time

Marine mammal species	Assessment of effect
Grey seal	3.6 grey seal associated with the Humber Estuary SAC (0.02% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2; or 2.4 grey seal associated with the Humber Estuary SAC (0.02% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

Summary for Impact 2

626. There would be no adverse effect from PTS or disturbance effects due to other construction activities on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.1.3 Impact 3: Effects from underwater noise and disturbance associated with construction vessels

627. During the construction phase there will be an increase in the number of vessels in the offshore project area; this is estimated to be up to a total of 35 vessels at any one time. The number, type and size of vessels will vary depending on the activities taking place at any one time.

628. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the array areas and offshore cable corridor.

629. The types of vessels that were recorded in the shipping and navigation study area (of the array sites plus 10 nautical mile (nm) buffer, and the offshore cable corridors plus 2 nm buffer) include fishing vessels, military vessels, dredgers, tugs, passenger vessels, cargo ships, tankers, vessels associated with either oil and gas or OWF projects, or recreational vessels. In total, an average of 151 vessels per day were recorded in the shipping and navigation study area in winter, and 167 per day in summer. The most common vessel in the study area was cargo vessels, accounting for more than half of all vessel traffic, while tankers accounted for 20% of all vessels.

630. With a peak of 35 vessels expected to be on site at any one time during the construction of North Falls, there will be approximately a 23% increase in the daily vessel presence during the winter period, and approximately a 21% increase during the summer period.

631. Noise measurements indicate that the most intense sound emissions from a cargo ship are typically low frequencies, up to and including 1kHz (Robinson et al., 2011) travelling at modest speed (between 8 and 16 knots) (Theobald et al., 2011). Underwater noise from construction vessels of a similar size also has the potential to disturb marine mammals in the short-term, in areas of increased vessel traffic, but are unlikely to produce any permanent auditory injury (PTS) (Pirotta et al., 2013).

632. The vessels will be slow moving (or stationary), and most noise emitted is likely to be of a lower frequency. Noise levels reported by Malme et al. (1989) and Richardson et al. (1995) for transiting large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. The potential risk of permanent auditory injury (PTS) in marine mammals as a result of vessel activity is highly unlikely, as the sound levels that are produced by vessels is well below the threshold for permanent injury (Southall et al., 2019). Trigg et al. (2020) found the predicted exposure of grey seals to shipping noise did not exceed thresholds for TTS.

633. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise due to vessel presence (PEIR Appendix 12.2, Volume III) and determine the potential effects on grey seal.

Impact 3a: Permanent auditory injury (PTS) due to construction vessels

634. The underwater noise modelling results for the predicted effect ranges and areas for PTS from the cumulative exposure of vessels within the site predicted <100m (0.031km^2) for grey seal. For SEL_{cum} calculations, the duration of the noise is also considered, with noise present for a worst case of 24-hours in a day.

635. The results of the underwater noise modelling do not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

636. The results of the underwater noise modelling indicate that grey seals would have to be <100m (precautionary maximum range) from the continuous noise source for 24 hours, to be exposed to noise levels that could induce PTS. It is therefore highly unlikely that any marine mammal would be at risk of PTS due to vessel noise. It should be noted that the predicted impact ranges are the distances which represent the 'onset' stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

637. An assessment of the maximum number of grey seal individuals that could be at risk of PTS, due to construction vessels, shows 0.001 grey seal associated with the Humber Estuary SAC (0.000004% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2, or 0.0004 grey seal (0.000002% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

638. There is the potential that up to 35 vessels may be present in the North Falls site at any one time during construction. As a worst case and unlikely scenario, an assessment for all 35 vessels has also been undertaken.

639. The predicted effect areas for cumulative PTS, for multiple construction vessels for grey seals is 1.1km^2.

640. An assessment of the maximum number of grey seal individuals that could be at risk of PTS, due to the maximum number of construction vessels at any one results in:

- 0.02 grey seal associated with the Humber Estuary SAC (0.0001% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2; or
- 0.01 grey seal associated with the Humber Estuary SAC (0.00006% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

Impact 3b: Disturbance effects due to construction vessels

641. Seals vary in their reaction to vessels depending on vessel type and proximity to haul out sites; however, disturbance (flushing behaviour) has been demonstrated at haul-out sites in the UK up to 200m away if there are pups present (Cates et al., 2017). Land-based disturbance has been shown to cause higher levels of disturbance compared to marine sources, and smaller, quiet

vessels like kayaks can cause the highest levels of flushing behaviour (Bonner, 2021). In areas of high vessel traffic, there are habituation effects and disturbance behaviour is generally reduced (Strong et al., 2010).

642. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any effects from underwater noise as a result of construction activities, other than piling, will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance for seals.

643. There is limited data on the potential for a behavioural response or disturbance from vessel noise. Based on the studies by Brandt et al. (2018) and Benhemma-Le Gall et al. (2021) that found that harbour porpoise could be disturbed up to 2km from construction vessels. As harbour porpoise are the most sensitive marine mammal species, this 2km (12.57km^2) potential disturbance range has been used for grey seal as a worst case, due to the absence of any other data to inform an assessment.

644. An assessment of the maximum number of grey seal individuals that could be at disturbed due to the maximum number of construction vessels at any one results in:

- 0.22 grey seal associated with the Humber Estuary SAC (0.001% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2; or
- 0.15 grey seal associated with the Humber Estuary SAC (0.001% of the Humber Estuary SAC population) based on the offshore cable corridor density of 0.012/km^2.

645. Construction vessel activity may generate underwater noise at sound levels and frequencies for sufficient durations to disturb marine mammals. Whilst the main focus of concern remains on the loudest noise sources such as impact piling, dredging etc., intense vessel activity during construction may also alter the acoustic habitat and disturb marine mammal species (Merchant et al., 2014). During the periods when piling is underway, vessel noise is unlikely to add an additional impact to those assessed for piling, as the vessels and vessel noise would be within the maximum impact areas assessed.

646. During baseline surveys (see Chapter 15 Shipping and Navigation, Volume I), the average recorded number of vessels per day in the summer was 167 (predominantly cargo). During the construction phase there may be an increase in the number of vessels in the area, however, this is likely to be offset by construction vessels/activity displacing existing vessel traffic as commercial vessels tend to deviate to avoid construction/decommissioning areas. The number, type and size of vessels will vary depending on the activities taking place at any one time. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the offshore project area only.

647. Jones et al. (2017) produced usage maps characterising densities of grey and harbour seals and ships around the British Isles, which were used to produce risk maps of seal co-occurrence with shipping traffic. The analysis indicates that rates of co-occurrence were highest within 50km of the coast, close to seal haul-

outs. When considering exposure to shipping traffic in isolation, the study found no evidence relating to declining seal population trajectories with high levels of co-occurrence between seals and vessels.

648. If the behavioural response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed, and therefore any impacts from underwater noise as a result of construction vessels will be both localised and temporary.

Summary for Impact 3

649. There would be no adverse effect from permanent changes in hearing sensitivity (PTS) and the potential for disturbance due to construction vessels on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.1.4 Impact 4: Barrier effects from underwater noise during construction

650. Underwater noise during construction could have the potential to create a barrier effect, preventing movement or migration of marine mammals between important feeding and / or breeding areas, or potentially increasing swimming distances if marine mammals avoid the site and go around it. However, the offshore project area is not located on any known migration routes for marine mammals.

651. The array areas are located 22.5km from the coast at closest point. The nearest seal haul-out site is at Gunfleet Sands, approximately 2.8km from the offshore cable corridor at its closest point. Note that this is a tidal haul-out site, and is only exposed at low tide, so is not a haul-out site that would be used for pupping.

652. Telemetry studies (see PEIR Appendix 12.1, Volume III) and the relatively low seal at sea usage (Carter et al., 2022; see PEIR Appendix 12.1, Volume III) in and around the offshore project area do not indicate any regular seal foraging routes through the sites.

653. The greatest potential barrier effect for marine mammals could be from underwater noise during piling. Piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles, and if installed in groups there could be time periods when piling is not taking place as piles are brought out to the site. There will also be potential delays for weather or other technical issues.

654. As it is predicted that marine mammals will return once the activity has been completed, and therefore any effects from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any barrier effects that could significantly restrict the movements of marine mammals.

655. Grey seals have foraging ranges of up to 448km (Carter et al., 2022), with foraging trips lasting up to 30 days (SCOS, 2021). Therefore, if there are any potential barrier effects from underwater noise, grey seals would be able to compensate by travelling to other foraging areas within their range.

656. There is unlikely to be any significant long-term impacts from any barrier effects, as any areas affected would be relatively small in comparison to the range of grey seals and would not be continuous throughout the offshore construction period. It is therefore considered that, for barrier effects as a result of

underwater noise, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal

6.3.3.1.5 Impact 5: Increased risk of collision with vessels during construction

657. During offshore construction, there will be an increase in vessel traffic within the array areas and offshore cable corridor. However, it is anticipated that vessels would follow an established shipping route to the relevant ports in order to minimise vessel traffic in the wider area.

658. Seals in and around the offshore project area and in the wider southern North Sea area would typically be habituated to the presence of vessels (given the existing levels of marine traffic, see Chapter 15 Shipping and Navigation, Volume I) and would be able to detect and avoid vessels.

659. Seals are able to detect and avoid vessels. However, vessel strikes are known to occur, possibly due to distraction whilst foraging and socially interacting, or due to the marine mammals' inquisitive nature (Wilson et al., 2007). Therefore, increased vessel movements, especially those outside recognised vessel routes, can pose an increased risk of vessel collision to marine mammals. Studies have shown that larger vessels are more likely to cause the most severe or lethal injuries, with vessels over 80m in length causing the most damage to marine mammals (Laist et al., 2001). Vessels travelling at high speeds are considered to be more likely to collide with marine mammals, and those travelling at speeds below 10 knots would rarely cause any serious injury (Laist et al., 2001).

660. There is currently limited information on the collision risk of marine mammals in the southern North Sea. To estimate the potential collision risk of vessels associated with North Falls during construction, the potential risk rate per vessel has been calculated for grey seals, which is then used to calculate the total risk to grey seals due to the presence of an additional 35 vessels at any one time during construction (See PEIR Chapter 12 Volume I, Section 12.6.1.5). The collision risk has been estimated by using data from the SMASS.

661. SMASS record and investigate all marine mammal strandings reported to them in Scotland. For the 2003 to 2020 period, SMASS identified the cause of death for a total of 470 of the 1,909 reported grey seal strandings. Of these, four died as a result of physical trauma following probable impact from a ship or boat. This results in a collision risk rate of 0.009.

662. To inform this assessment, the total number of grey seals in UK waters has been compared against the total vessels present in UK waters, as well as the potential collision risk rate of each species based on the SMASS data. The total UK populations are taken from IAMMWG (2022) for all cetacean species, and the total UK populations for seal species are taken from SCOS (2021). The total presence of vessels in UK waters is taken from the total vessel transits within the 2015 AIS data, which is the latest publicly available.

663. The assessment (See PEIR Chapter 12, Section 12.6.1.5 and Table 12.63, Volume I) predicts that 0.38 individual grey seal may be at risk of collision (0.002% of the Humber Estuary SAC population)

664. This is a highly precautionary assumption, as it is unlikely that marine mammals in the offshore project area would be at increased collision risk with vessels during construction, considering the minimal number of vessel movements

compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

665. In addition, vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Vessel operators will use best practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever possible.

666. There would be no adverse effect for any increase in vessel collision risk during construction on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.1.6 Impact 6: Changes to water quality

667. Potential changes in water quality during construction could occur through:

- Deterioration in water quality due to an increase in suspended sediment associated with seabed preparation for the installation of foundations, array, and interconnector cables;
- Deterioration in water quality due to an increase in sediment concentrations due to drill arisings for installation of piled foundations for wind turbines and OSP;
- Deterioration in water quality due to increases in suspended sediment associated with the installation of the offshore export cable; and
- Deterioration in water quality associated with release of sediment bound contaminants.

668. North Falls are committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction activities. As a result, an outline PEMP will be developed to accompany the DCO application. The final PEMP would be agreed with the MMO prior to construction and would include, for example, measures to control accidental release of drilling fluids whilst ensuring that any chemicals used are listed on the OSPAR List of Substances Used and Discharged Offshore which are considered PLONOR (OSPAR, 2021).

669. Marine mammals often inhabit turbid environments and cetaceans utilise sonar to sense the environment around them and there is little evidence that turbidity affects cetaceans directly (Todd et al., 2014).

670. Increased turbidity is unlikely to have a direct impact on marine mammals that often inhabit naturally turbid or dark environments. This is likely because other senses are utilised, and vision is not relied upon solely.

671. Any direct impacts to marine mammals as a result of any contaminated sediment during construction activities are unlikely as any exposure is more likely to be through potential indirect impacts via prey species.

672. Taking into account the distance between the Humber Estuary SAC and North Falls, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal due to any changes in water quality during the construction of North Falls.

6.3.3.1.7 Impact 8: Changes to prey availability and habitat quality

673. The potential effects on prey species during construction can result from physical disturbance and loss of seabed habitat; increased SSC and sediment re-deposition; and underwater noise. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of these impact pathways on the relevant fish and shellfish species and concludes impacts of negligible to minor adverse significance in EIA terms.

674. During construction activities, the worst-case footprint for disturbance would be 6.1km^2, constituting only 0.000017% of the total SNS SAC area. Predominantly medium and coarse-grained sediment type were found at North Falls (see Chapter 8 Marine Geology, Oceanography and Physical Processes, VolumeI), typically remaining close to the seabed and settling quickly once disturbed. The worst-case level of sediment smothering and deposition would be approximately <1mm, short-lived (minutes) and localised. Increases in suspended sediment are therefore expected to cause localised and short-term increases in SSC only and not significantly affect fish species.

675. The data and analysis in PEIR Chapter 9 Marine Water and Sediment Quality (Volume I) indicates that levels of contaminants within the North Falls offshore site are low and do not contain elevated levels to cause concern.

676. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I), provides an assessment of the potential underwater noise impacts on fish and shellfish species and predicts that impacts would be of a temporary nature (see Chapter 11 (Volume I) for a detailed assessment of underwater noise impacts on fish species). Potential sources of underwater noise and vibration during construction include piling, increased vessel traffic, seabed preparation, rock placement and cable installation. Of these, piling is considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse impacts on fish.

677. Piling could have mortality/injury effects, but under a realistic fleeing animal assumption, ranges at which mortality/potential mortal injury and recoverable injury could occur would be reduced to less than 100m (see PEIR Chapter 11 Volume I, Table 11.21 to 11.34). Therefore, any effect on prey populations would be highly localised.

678. The outputs of the underwater noise modelling for the spatial worst-case scenario indicate that TTS may occur at distances up to 16km and 17km assuming a fleeing animal scenario (single pin pile and sequential pin pile installation), increasing to up to 33km and 39km when considering a stationary receptor (single monopile and sequential monopiles installation). Behavioural responses would be expected within these ranges and potentially in wider areas depending on the hearing ability of the species under consideration (see PEIR Chapter 11 Volume I, Table 11.21 to 11.34). However, the potential for behavioural response does not indicate that prey would actually leave the area (and in many cases this would not be possible within the duration of a piling event).

679. It is unlikely that there would be significant changes to prey over the entire area. It is more likely that effects would be restricted to an area around the working sites. There is unlikely to be any additional displacement of grey seal as a result

of any changes in prey availability during piling as grey seal would also be disturbed from the area.

680. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of the potential changes of fishing activity by the presence of safety zones associated with the project during construction. The predicted impact would be of negligible impact given the short-term and temporary nature of the construction phase.

681. Grey seal are opportunistic feeders, preying on a variety of species, dominated by sandeel. Within the southern North Sea, diet is more varied in composition where grey seals also prey on flat fish, sandy benthic, large gadid prey and scorpion fish (the latter mainly during autumn/winter) (Wilson & Hammond, 2019).

682. Despite the relatively large grey seal foraging ranges of 448 km (Carter et al., 2022), the potential impacts of physical disturbance, temporary habitat loss, increased SSC, re-mobilisation of contaminated sediment on changes in prey availability at North Falls are localised and short in duration and would therefore be unlikely to affect grey seals in the Humber Estuary SAC.

683. It is highly unlikely that there would be significant changes to prey over the entire area. It is more likely that effects would be restricted to an area around the working sites, and the potential areas for habitat loss.

684. Taking this into account the precautionary approach, along with the separation distance from the Humber Estuary SAC and no potential for any direct effect on the Humber Estuary SAC, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal as a result of any changes to prey availability during construction for North Falls.

6.3.3.2 Potential effects during O&M

685. The potential effects during O&M that have been assessed for are:

- Auditory injury and disturbance or behavioural impacts resulting from operational WTGs;
  - Permanent auditory injury (PTS).
  - Disturbance.
- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during maintenance activities, including cable protection and cable reburial;
  - Permanent auditory injury (PTS).
  - Disturbance.
- Impacts resulting from the deployment of vessels:
  - Underwater noise and disturbance from vessels;
    - Permanent auditory injury (PTS).
    - Disturbance.
- Vessel interaction (collision risk).
- Barrier effects as a result of underwater noise;

- Changes to water quality; and
- Changes to prey resource and habitat quality.

6.3.3.2.1 Impact 1: Impacts from underwater noise associated with operational WTGs

686. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during the operational phase and determine the potential effects on marine mammals (PEIR Appendix 12.2 Volume III).

Impact 1a: Permanent auditory injury (PTS) due to operational wind turbine noise

687. The underwater noise modelling results for the predicted effect ranges and areas for PTS from the cumulative exposure of operational WTGs, show potential effect range is <100m (0.031km^2) for grey seals. For SEL_{cum} calculations, the duration of the noise is also considered, with operating WTGs for a worst case of 24-hours in a day.

688. The results of the underwater noise modelling do not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

689. It is important to note that PTS is unlikely to occur in grey seals, as the modelling indicates that an individual would have to remain <100m from a WTG for 24 hours for any potential risk of PTS. Therefore, PTS as a result of operational WTG noise is highly unlikely. It should be noted that the predicted impact ranges are the distances which represent the 'onset' stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

690. An assessment of the maximum number of individuals that could be at risk of PTS, due to a single operational WTG, is 0.0006 grey seal associated with the Humber Estuary SAC (0.000004% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.

691. More than one WTG will be operating at the same time, and therefore an assessment of the potential for auditory injury, due to all operational WTGs, is required. There is the potential for either 72 of the smallest WTGs, or 40 of the largest WTGs to be installed for the North Falls project. The potential auditory effect ranges are the same for the range of WTGs included in the North Falls design envelope, and therefore the worst case would be for a total of 72 operational WTGs.

692. The potential areas of PTS for all operational WTGs for grey seals is 2.26km^2. An assessment of the maximum number of individuals that could be at risk of PTS from all operational WTGs shows 0.04 grey seal associated with the Humber Estuary SAC (0.0003% of the Humber Estuary SAC population) based on the northern array area density of 0.018/km^2.

693. The indicative separation distance between WTGs would be a minimum of 0.82km to 1.685km, depending on WTG size, therefore there would be no overlap in the potential impact range of <100m (<0.1km) around each WTG.

Impact 1b: Disturbance effects due to operational wind turbine noise

694. Currently available data indicates that there is no lasting disturbance or exclusion of seals around OWF sites during operation (Diederichs et al., 2008; Lindeboom et al., 2011; Marine Scotland, 2012; McConnell et al., 2012; Russell et al., 2014; Scheidat et al., 2011; Teilmann et al., 2006; Tougaard et al., 2005, 2009a, 2009b). Data collected suggests that any behavioural responses for seals may only occur up to a few hundred metres away (Touggard et al., 2009b; McConnell et al., 2012).

695. Monitoring studies at Nysted and Rødsand have also indicated that operational activities have had no impact on regional seal populations (Teilmann et al., 2006; McConnell et al., 2012). Seals have been shown to forage within operational OWFs (e.g. Lindeboom et al., 2011; Russell et al., 2014), indicating no restriction to movements in operational OWF sites.

696. Given the results of the monitoring studies listed above, it is not considered that disturbance effects would be significant.

Summary for Impact 1

697. There are no adverse effects for permanent changes in hearing sensitivity (PTS) and potential for disturbance due to operational WTG noise on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.2.2 Impact 2: Impacts from underwater noise associated with O&M activities

698. Disturbance to marine mammals foraging at sea may occur as a result of displacement from vessel traffic and sources of noise, including those associated with O&M activities.

699. The potential for PTS is only likely in very close proximity to cable laying or rock placement activities, and if the marine mammal remains within close proximity for 24 hours. Therefore, it is highly unlikely for there to be any PTS due to these activities.

700. The effects from additional cable laying and protection are temporary in nature and will be limited to relatively short periods during the O&M phase. Disturbance responses are likely to occur at significantly shorter ranges than construction noise. Any disturbance is likely to be limited to the area in and around where the actual activity is taking place. The requirements for any potential maintenance work are currently unknown, however, the work required, and impacts associated with underwater noise and disturbance from activities during O&M would be less than those during construction.

701. As there is expected to be less noisy activities during the operation phase than is required during construction (see Section 6.3.3.1.2), it is therefore likely to cause less disturbance.

702. There is no adverse effect for permanent changes in hearing sensitivity (PTS) and potential disturbance due to these operational activities on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.2.3 Impact 3: Impacts from underwater noise and disturbance associated with O&M vessels

703. The potential for PTS is only likely in very close proximity to vessels (<100m) and if the marine mammal remains within close proximity for 24 hours.

704. The specific requirements for any potential maintenance work are currently unknown, however the work required is likely to be similar to those activities assessed for construction. During operation, there may be up to 22 vessels in the North Falls project area at any one time, compared to the 35 vessels that would be on site during construction. Therefore, the potential effects associated with underwater noise and disturbance from vessels during O&M would be less than of those during construction (see Section 6.3.3.1.3).

705. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of O&M activities will be both localised and temporary.

706. There are no adverse effects on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.2.4 Impact 4: Barrier effects from underwater noise during O&M

707. The indicative separation distance between turbines would be a minimum of 0.82km to 1.685km, depending on WTG size, therefore there would be no overlap in the potential impact range of <100m around each turbine and there would be adequate room for marine mammals to move through the array areas.

708. While seal species are known to transit along the coastline, there would be sufficient room for them to swim through the array through the operational period. In addition, seal species are known to be present and forage within operational array areas (see Section 6.3.3.2.1), and therefore it is concluded that the presence of North Falls infrastructure would not form a barrier to any movement of marine mammal species.

709. Therefore, no barrier effects as a result of underwater noise during O&M are anticipated, and there are no adverse effects on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.2.5 Impact 5: Increased risk of collision with vessels during operation

710. It is estimated that the maximum number of vessels that could be required on site at any one-time during O&M could be up to 22, with the potential for up to 1,587 vessel round trips per year.

711. The number of marine mammals at risk of collision, per vessel, in UK waters, has been calculated as described for the construction phase (Section 6.3.3.1.5), and has been used to calculate the number of each marine mammal species at risk of collision from the total number of vessel movements per year that are currently expected during the O&M phase. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk.

712. It is estimated that 0.6 grey seal (0.004% of the Humber Estuary SAC population) could be at risk of collision (see Table 12.81, Chapter 12 Volume I of the PEIR). This is a highly precautionary assumption, as it is unlikely that

grey seal in the offshore project area would be at increased collision risk with vessels during the O&M phase, considering the minimal number of vessel movements compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

713. In addition, vessel operators will use best practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever possible.

714. For any increase in vessel collision risk during O&M, assessments have indicated there are no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.2.6 Impact 6: Changes to water quality

715. Any effects on grey seal would be less than those for construction (see section 6.3.3.1.6) as activities during O&M which disturb the seabed would be less frequent and more localised than during construction.

716. Therefore, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal as a result of any changes to water quality during O&M for North Falls.

6.3.3.2.7 Impact 7: Changes to prey availability and habitat quality

717. Taking into account the distance between North Falls and the Humber Estuary SAC there are no potential direct changes to prey resource within the SAC. Any potential changes to prey availability within or in proximity to North Falls during O&M would be less than those assessed during construction (see section 6.3.3.2.7) as there would be no piling, fewer disturbing activities etc.

718. Therefore, there would be no adverse effects on grey seal and on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal due to changes to prey resource from O&M at North Falls.

6.3.3.3 Potential effects during decommissioning

719. Potential effects on grey seals associated with decommissioning have not been assessed in detail, as further assessments will be carried out ahead of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements. A detailed decommissioning programme will be provided to the regulator prior to construction that will give details of the techniques to be employed and any relevant mitigation measures required.

720. Decommissioning would most likely involve the removal of the accessible installed components comprising all of the wind turbine components; part of the foundations (those above seabed level); and the sections of the infield cables close to the offshore structures, as well as sections of the offshore export cables. The process for removal of foundations is generally the reverse of the installation process. There would be no piling, and foundations may be cut to an appropriate level.

721. Potential effects during decommissioning would most likely include:

- Underwater noise and disturbance from decommissioning activities;

- Underwater noise and disturbance from vessels;
- Barrier effects as a result of underwater noise;
- Increased collision risk with vessels;
- Barrier effects due to underwater noise during decommissioning;
- Changes to water quality; and
- Changes to prey resource.

722. It is not possible to provide details of the methods that will be used during decommissioning at this time. However, it is expected that the activity levels will be comparable to construction (with the exception of pile driving noise which would not occur).

723. Therefore, the potential effects on grey seals during decommissioning would be the same or less than those assessed for construction due to the processes of decommissioning potentially being the reverse of the installation, without the need for piling.

6.3.3.4 Potential in combination effects

724. The following in-combination assessment has been undertaken based on the CEA Screening Appendix, and Section 12.9 of PEIR Chapter 12 (Volume I).

725. The in-combination effects assessed are:

- Disturbance from underwater noise due to the following sources;
    - Piling at other OWFs;
    - Construction activities at other OWFs;
    - Geophysical surveys for OWFs;
    - Aggregate extraction and dredging;
    - Oil and gas installation projects;
    - Oil and gas seismic surveys;
    - Subsea cable and pipelines;
    - UXO clearance.
- Barrier effects of other OWFs;
- Increased collision risk with vessels; and
- Changes in prey resource.

6.3.3.4.1 In-combination impact 1: Disturbance from underwater noise

In-combination impact 1a: Assessment of underwater noise from piling at other OWFs

726. A list of UK and European OWF projects that may the potential for overlapping piling with North Falls is provided in PEIR Chapter 12 (Volume I) (Table 12.87), and has been used to inform the assessment for in-combination effects due to piling at other OWFs.

727. For grey seal at the Humber Estuary SAC, other OWFs were included in the assessment against the SAC population where the Carter *et al*. (2022) densities for the individuals associated with the Humber Estuary SAC show presence within the 5km x 5km grid cells that overlap with the other OWF (or where there is a presence of seals within the potential disturbance area of the other OWF, e.g. within 25km for other OWFs that may be piling). Figure 6.4 shows the Humber Estuary SAC relative densities against all OWFs screened in for assessment.

728. Of the 17 UK and European OWFs screened in for having a construction period that could potentially overlap with the construction of the Project, the below are relevant to grey seal and could be piling at the same time, which is currently estimated to take place in 2028 to 2029 for North Falls;

- Berwick Bank;
- DEP;
- Dunkerque;
- Five Estuaries;
- Hornsea Project Four;
- Outer Dowsing; and
- SEP.

729. Of these, all are shown to have grey seal associated with the Humber Estuary SAC present within the project areas.

730. This short list of OWF projects that could be piling at the same time as North Falls could change as projects develop, but this is the best available information at the time of writing, and reflects the limitations and constraints to project delivery.

731. The commitment to the mitigation agreed through the MMMP for piling would reduce the risk of physical injury or permanent auditory injury (PTS) for all marine mammals.

732. For grey seal, the in-combination assessment is based on the reported disturbance range of harbour seal to piling;

- A potential disturbance range of 25km for seal species, with a potential disturbance area of 1,963.5km^2.

733. It should be noted that the potential areas of disturbance assume that there is no overlap in the areas of disturbance between different projects and are therefore highly conservative. For example, Five Estuaries and North Falls are within 10km of each other, SEP and DEP are approximately 10km from each other at their closest points and Outer Dowsing is less than 15km from DEP

734. The approach to the in-combination assessment for piling at OWFs is based on the potential for single piling at each OWF at the same time as single piling at the North Falls. This approach allows for some of the OWFs not to be piling at the same time, while others could be simultaneously piling (further information is available in the PEIR Appendix 12.4, Volume III). This is considered to be the

most realistic worst case scenario, as it is highly unlikely that all other OWFs would be simultaneously piling at exactly the same time as piling at North Falls.

735. It is important to note the actual duration for active piling time which could disturb marine mammals is only a very small proportion of the potential construction period, of up to approximately 76 days for North Falls, based on the estimated maximum duration to install individual piles.

736. As shown in Table 6.63 below, North Falls accounts for a very small proportion of grey seal that may be disturbed due to OWF piling (a total of 35.3 individuals out of the 2,854.9 that may be disturbed in total, or 1.2% of the total seals at risk of disturbance). For the DCO application, the below assessment will be updated to take account of further information on project dates, and the assessment will be amended accordingly. In the case that a significant proportion of the Humber Estuary SAC grey seal population are at risk of disturbance at that stage, population modelling would be undertaken (using Population Consequences of Disturbance (PCoD)) to determine whether there is the potential for a population level effect.

Table 6.63 Quantitative assessment for in-combination disturbance for grey seal from piling at other OWFs

Project	Grey seal density (based on the Humber Estuary SAC relative densities) (/km^2)	Effect area (km^2)	Maximum number of grey seal potentially disturbed during single piling
North Falls	0.018	1,963.5	35.3
Berwick Bank	0.003	1,963.5	5.9
DEP	0.363	1,963.5	712.8
Dunkerque	0.003	1,963.5	5.9
Five Estuaries	0.005	1,963.5	9.8
Hornsea Project Four	0.232	1,963.5	455.5
Outer Dowsing	0.409	1,963.5	803.1
SEP	0.421	1,963.5	826.6
Total number of seals (without NF)			2,854.9 2,813.7
Percentage of Humber Estuary SAC (without NF)			18.42% 18.16%

737. It is highly likely that other OWFs within the SNS SAC would require mitigation to manage the effect of in-combination disturbance, reducing the potential for significant disturbance. For the DCO application, the assessment will be updated to take account of any updates on project level mitigation commitments or marine licence conditions from the in-combination projects.

738. Should the population modelling (using PCoD, to be undertaken to inform the final RIAA) show a potential adverse effect on integrity, NFOW will seek to agree mitigation with Natural England and the MMO, in order to ensure there will be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

In-combination impact 1b: Assessment of underwater noise from construction activities (other than piling) at other OWFs

739. All OWFs with construction dates that have the potential to overlap with the construction dates for North Falls have the potential for other construction activities (such as seabed preparation, dredging, trenching, cable installation, rock placement, drilling and vessels) to occur at the same time as other construction activities at North Falls.

740. For grey seal at the Humber Estuary SAC, other OWFs were included in the assessment against the SAC population where the Carter *et al*. (2022) densities for the individuals associated with the Humber Estuary SAC show presence within the 5km x 5km grid cells that overlap with the other OWF (or where there is a presence of seals within the potential disturbance area of the other OWF).

741. OWFs screened in for other construction activities that could have an in-combination effect with other construction activities at North Falls was narrowed down to Dogger Bank South (East and West) and Dolphyn Project – Pre commercial.

742. While the other OWFs that have been assessed under the in-combination piling assessment have the potential for overlapping construction phases, as well as those listed above, they are already assessed under a worst case of piling overlaps. As the disturbance areas for piling are significantly larger than the disturbance areas for other constriction activities, an assessment of piling at those projects would produce a much higher potential for in-combination effect than an assessment for in-combination effects with other construction activities, and they are therefore not included under the assessment for other construction activities as set out below.

743. Noise sources which could cause potential disturbance during OWF construction activities, other than pile driving, can include vessels, seabed preparation, cable installation works and rock placement. The potential effect area, based on the worst case disturbance range of 4km, for up to four activities taking place at the same time, with an area of 201.1km^2, is used to inform the assessment.

Table 6.64 Quantitative assessment for in-combination disturbance for grey seal due to construction activities at other OWFs

Project	Grey seal density (based on the Humber Estuary SAC relative densities) (/km^2)	Effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.018	1,963.5	35.3
Dogger Bank South (East and West)	0.080	201.1	16.1
Dolphyn Project - pre-commercial (floating)	0.0004	201.1	0.1
Total number of seals (without NF)			51.4 16.1
Percentage of Humber Estuary SAC (without NF)			0.33% 0.10%

744. It should be noted that, while the projects included within the in-combination assessment were screened in on the basis of current knowledge of their possible construction or activity windows, it is very unlikely that all activities would be taking place on the same day or in the same season, and therefore this likely represents an over-precautionary and worst case estimate of the marine mammals that could be at risk of disturbance during the three year offshore construction period of North Falls.

In-combination impact 1c: Assessment of disturbance from other industries and activities

745. During the construction period for North Falls, there is the potential for disturbance to grey seals associated with other potential noise sources, including:

- Geophysical surveys associated with other OWFs;
- Aggregate extraction and dredging;
- Oil and gas installation projects;
- Oil and gas seismic surveys;
- Subsea cable and pipelines;
- Other marine renewable projects (such as wave and tidal projects);
- Disposal sites; and
- UXO clearance.

746. For the installation of oil and gas infrastructure, marine renewable projects, and disposal sites, all potential projects have been screened out. Further information on the CEA screening (and these results) are provided in the PEIR Appendix 12.4 (Volume III).

747. As outlined in the PEIR Appendix 12.4 (Volume III), OWF geophysical surveys using SBPs and USBL systems have the potential to disturb marine mammals and have therefore been screened into the in-combination assessment, as a precautionary approach. The potential disturbance range used in the cumulative assessment is based on the SNCB guidance for assessment for harbour porpoise.

748. Assessments for the RoC HRA for the SNS SAC (BEIS, 2020), modelled the potential for disturbance due to the use of a SBP, and results indicated that there is the potential for a possible behavioural response in harbour porpoise at up to 3.77km (44.65km^2) from the source. The current guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC et al., 2020) recommends the use of an EDR of 5km (78.54km^2) for geophysical surveys.

749. As a worst case, it has been assumed that all grey seal within 5km of the survey source, a total area of 78.54km^2 could be disturbed.

750. For geophysical surveys with sub-bottom profilers, it is realistic and appropriate to base the assessments on the potential effect area around the vessel, as the potential for disturbance would be around the vessel at any one time. Seals

would not be at risk throughout the entire area surveyed in a day, as animals would return once the vessel had passed, and the disturbance had ceased.

751. It is currently not possible to estimate the location or number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. It is therefore assumed, as a worst case scenario, that there could potentially be up to two geophysical surveys in the North Sea at any one time, during construction of North Falls, with a total disturbance area of 157.1km^2.

752. As the location of the potential geophysical surveys is currently unknown, the following assessment for grey seal uses the average density estimate across the Carter *et al.* (2022) relative density dataset for the Humber Estuary SAC of 0.053/km^2. This therefore assumes that there could be up to two geophysical surveys within the area at which grey seal associated with the Humber Estuary SAC may be present.

Table 6.65 Quantitative assessment for in-combination disturbance of marine mammals due to up to two geophysical surveys at OWFs

Potential in-combination effect	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	1,963.5	35.3
Up to two geophysical surveys	157.08	8.3
Total number of seals (without NF)		43.7 8.3
Percentage of Humber Estuary SAC (without NF)		0.28% 0.05%

753. Taking into account the small potential effect ranges, distances of the aggregate extraction and dredging projects from North Falls, the potential for contribution to in-combination effects is very small. Therefore, risk of PTS for grey seals from aggregate extraction and dredging has been screened out from further consideration in the in-combination assessment.

754. As a precautionary approach, a total of six aggregate extraction and dredging projects are included in the CEA for the potential in-combination disturbance (see the PEIR Appendix 12.4, Volume III).

755. As outlined in the BEIS (2020) RoC HRA for the SNS SAC, studies have indicated that harbour porpoise may be displaced by dredging operations within 600m of the activities (Diederichs et al., 2010). As a worst case assessment, a disturbance range of 600m for grey seal has been assumed for up to six operational aggregate projects at the same time as North Falls construction. This would result in a potential disturbance area of 1.13km^2 for each project, or up to 6.8km^2 for all six aggregate projects.

Table 6.66 Quantitative assessment for in-combination disturbance of marine mammals due to aggregate and dredging projects

Potential in-combination effect	Grey seal density (based on the Humber Estuary SAC relative densities) (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls (piling)	0.018	1,963.5	35.3
Aggregate and dredging projects (1.13km^2) disturbance area per project)	0.053	6.8	0.4
Total number of seals (without NF)			35.7 0.3
Percentage of Humber Estuary SAC (without NF)			0.23% 0.002%

756. It is currently not possible to estimate the number of potential oil and gas seismic surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. Therefore, it has been assumed that at any one time, up to two seismic surveys could be taking place at the same time.

757. This assessment for the potential disturbance due to oil and gas seismic surveys is based on the following:

- There is little available information on the potential for disturbance from seismic surveys for grey seal, however, observations of behavioural changes in other seal species have shown avoidance reactions up to 3.6km from the source for a seismic survey (Harris et al., 2001). A more recent assessment of potential for disturbance to seal species, as a result of seismic surveys, shows potential disturbance ranges from 13.3km to 17.0km from source (BEIS, 2020). These ranges are based on modelled impact ranges, using the National Marine Fisheries Service Level B harassment threshold of 160dB, for a noise source of 3,070 cubic inches, 4,240 cubic inches, or 8,000 cubic inches.
- A potential disturbance range of 17.0km (or disturbance area of 907.9km^2 for one survey, and 1,815.8km^2 for up to two seismic surveys) will therefore be applied to grey seal due to a lack of species-specific information.

758. As the location of the potential seismic surveys is currently unknown, the following assessments for grey seal use the average density estimate across the Carter *et al.* (2022) relative density dataset for the Humber Estuary SAC of 0.053/km^2. This therefore assumes that there could be up to two seismic surveys within the area at which grey seal associated with the Humber Estuary SAC may be present.

Table 6.67 Quantitative assessment for in-combination disturbance of marine mammals due to up to two oil and gas seismic surveys

Potential in-combination effect	Grey seal density (based on the Humber Estuary SAC relative densities) (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.018	1,963.5	35.3
Up to two seismic surveys	0.053	1,815.8	96.2
Total number of seals (without NF)			131.6 96.2
Percentage of Humber Estuary SAC (without NF)			0.85% 0.62%

759. Only one subsea pipeline has been screened into the in-combination assessment; Sea Link. This project is currently at scoping stage and therefore there is limited information available on potential effects and disturbance ranges for which to inform an in-combination assessment with North Falls.

760. The disturbance ranges that could be generated during the cabling works and vessels would be up to 4km (with a disturbance area of 50.3km^2), for all marine mammal species.

761. The density for the Sea Link project has been estimated based on the Carter *et al.* (2022) relative density data for the Humber Estuary SAC, with an estimated density (for only those grey seals that are associated with the Humber Estuary SAC) of 0.013/km^2.

Table 6.68 Quantitative assessment for in-combination disturbance of grey seals due to cable and pipeline projects

Potential in-combination effect	Grey seal density (based on the Humber Estuary SAC relative densities) (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls (Piling)	0.018	1,963.5	35.3
Cable and pipeline projects	0.053	50.3	2.7
Total number of seals (without NF)			38.0 2.7
Percentage of Humber Estuary SAC (without NF)			0.25% 0.02%

762. It is currently not possible to estimate the number of potential UXO clearance events that could be undertaken at the same time as construction and potential piling activity at North Falls, and therefore, on a worst case basis, the potential for one high-order clearance and one low-order clearance has been assessed as having the potential to take place at the same time.

763. The potential effect area during a single UXO clearance event, based on the modelled worst case effect range at North Falls for TTS / fleeing response

(weighted SEL) of 22.0km (1,520.5km^2) for high-order clearance and 0.8km (2.01km^2) for low-order clearance.

764. However, as outlined in the BEIS (2020) RoC HRA, due to the nature of the sound arising from the detonation of UXO, i.e. each blast lasting for a very short duration, marine mammals, are not predicted to be significantly displaced from an area, any changes in behaviour, if they occur, would be an instantaneous response and short-term. Guidance suggests that disturbance behaviour is not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC, 2010).

765. Mitigation measures required for UXO clearance include the use of low-order clearance techniques, which could include a small donor charge, rather than full high-order detonation which is only used as a last resort. It is therefore highly unlikely that more than one UXO high-order detonation would occur at exactly the same time or on the same day as another UXO high-order detonation, even if they had overlapping UXO clearance operation durations. The in-combination assessment is therefore based on potential for disturbance from one UXO high-order detonation without mitigation (worst case), as well as one low-order clearance event.

766. As the location of the potential UXO clearances are currently unknown, the following assessment for grey seal uses the average density estimate across the Humber Estuary SAC of 0.053/km^2.

Table 6.69 Quantitative assessment for in-combination disturbance of grey seals due to UXO clearance

Potential in-combination effect	Grey seal density (based on the Humber Estuary SAC relative densities) (/km^2)	Potential in-combination effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.018	1,963.5	35.3
One high-order UXO detonation	0.053	1,520.5	80.6
One low-order UXO detonation	0.053	2.01	0.1
Total number of seals (without NF)			116.0 80.7
Percentage of Humber Estuary SAC (without NF)			0.75% 0.52%

Summary of in-combination effect 1: assessment of disturbance from all noisy activities associated with offshore industries

767. Each of the above described other noise sources are quantitively assessed together in Table 6.70.

768. It should be noted that while the projects included within the in-combination assessment for disturbance from other activities and industries were done so based on the current knowledge of their possible construction or activity windows, and it is very unlikely that all activities would be taking place on the same day or in the same season, and therefore this likely represents an over-

precautionary and worst case estimate of the grey seals that could be at risk of disturbance during the three year offshore construction period of North Falls.

769. As shown in Table 6.70 below, North Falls accounts for a very small proportion of grey seal that may be disturbed due to OWF piling (a total of 35.3 individuals out of the 3,053.3 that may be disturbed in total, or 1.2% of the total seals at risk of disturbance). For the DCO application, the assessment will be updated to take account of further information on project dates and any detail on project level mitigation commitments or marine licence conditions from the in-combination projects. In the case that a significant proportion of the Humber Estuary SAC grey seal population are at risk of disturbance at that stage, population modelling would be undertaken (using PCoD) to determine whether there is the potential for a population level effect, and therefore whether there is the potential for the FCS of grey seal to be affected.

770. As shown in the above assessments, the majority of grey seal at risk of disturbance are from OWF piling, with those projects that are within close proximity of the Humber Estuary SAC contributing a large proportion of the in-combination disturbance. Therefore, there is limited opportunity for North Falls to significantly reduce the overall potential disturbance effect to the Humber Estuary SAC population.

771. Should the population modelling (using PCoD, to be undertaken to inform the final RIAA) show a potential adverse effect on integrity, NFOW will seek to agree mitigation with Natural England and the MMO, in order to ensure there will be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

Table 6.70 Quantitative assessment for all noisy activities with the potential for in-combination disturbance effects for grey seals

Noisy activity	Maximum number of grey seal potentially disturbed
North Falls	35.3
Piling at other OWFs	2,813.7
Construction activities at other OWFs	16.1
Up to two geophysical surveys	8.3
Aggregates and dredging	0.4
Up to two oil and gas seismic surveys	96.2
Subsea cables and pipelines	2.7
UXO clearance	80.7
Total number of individuals (without North Falls)	3,053.4 3,018.1
Percentage of Humber Estuary SAC (without North Falls)	19.71% 19.48%

6.3.3.4.2 In-combination impact 2: Barrier effects

772. It is important to note that the OWFs and other noise sources included in the in-combination assessment are spread over the wider area of the North Sea. Taking into account the locations of the OWFs and other noise sources from North Falls, the maximum underwater effect ranges for disturbance at other projects would not overlap with the maximum underwater effect ranges for

disturbance at North Falls during piling and construction. Therefore, there is no potential for underwater noise from North Falls, other OWFs and noise sources to result in a barrier of movement to grey seal.

773. There would be no adverse effect due to barrier effects on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal.

6.3.3.4.3 In-combination impact 3: Increased collision risk with vessels

774. The increased collision risk even using a very precautionary approach, has an effect significance of minor adverse (with mitigation), with a low number of marine mammals at risk.

775. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore there would be no increased collision risk as the increase in the number OWF vessels would be relatively small compared to the baseline levels of vessel movements in these areas.

776. Once on-site, OWF vessels would be stationary or slow moving, as they undertake the activity they are associated with. Therefore, the risk of any increased collision risk for grey seals would be negligible, if any.

777. Vessels associated with aggregate extraction and dredging are large and typically slow moving, using established transit routes to and from ports. Therefore, the potential increased collision risk with vessels is considered to be extremely low or negligible. Therefore, increased collision risk from aggregate extraction and dredging has been screened out from further consideration in the in-combination assessment.

778. Good practice measures, as implemented for North Falls, would ensure any risk of vessels colliding with grey seals is avoided.

779. Therefore, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal as a result of collision risk.

6.3.3.4.4 In-combination impact 4: Changes in prey resource

780. For any potential changes to prey resources, it has been assumed that any potential effects on grey seal prey species from underwater noise, including piling, would be the same or less than those for grey seal. Therefore, there would be no additional in-combination effects other than those assessed for grey seal, i.e. if prey are disturbed from an area as a result of underwater noise, grey seal will be disturbed from the same or greater area. As a result any changes to prey resources would not affect grey seal as they would already be disturbed from the area.

781. Any effects to prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat for prey species in the surrounding area.

782. Taking into account the assessment for North Falls alone (Section 6.3.3.1.7), and assuming similar effects for other projects and activities, along with the range of prey species taken by grey seal and the extent of their foraging ranges, there would be no potential for in-combination effect on grey seal populations as a result of changes to prey resources.

783. Therefore, there would be no adverse effect on the integrity of the Humber Estuary SAC in relation to the conservation objectives for grey seal as a result of changes in prey resource

6.4 The Wash and North Norfolk Coast SAC

6.4.1 Site overview

784. The Wash, located on the east coast of England, is the largest embayment in the UK, and the extensive intertidal flats both within The Wash, and extending along the north Norfolk coast, provide ideal conditions for harbour seal breeding and haul-out sites. Harbour seal are a primary reason for the designation of The Wash and North Norfolk Coast SAC.

785. The Wash and North Norfolk Coast SAC is located, at closest point, 132km from the closest point at North Falls. Therefore, there is no potential for direct effects on the SAC as a result of the construction, operation, maintenance or decommissioning of North Falls. However, due to the foraging range of harbour seals, there is the potential for effects on foraging harbour seal from The Wash and North Norfolk Coast SAC in the vicinity of North Falls.

6.4.1.1 Qualifying features

6.4.1.1.1 Harbour seal

786. Principal harbour seal haul-out sites in The Wash and North Norfolk Coast SAC include Blakeney Point and The Wash (SCOS, 2020).

787. In the 2021 August seal haul-out count for The Wash sites and Blakeney Point, an average of 2,667 harbour seal were counted within The Wash, and an average of 181 harbour seals at the Blakeney Points site, with a total average count of 2,848 for the haul-out sites associated with The Wash and North Norfolk Coast SAC (SCOS, 2021).

788. No harbour seal sightings were confirmed during the site-specific aerial surveys, however there was a total of 23 individuals within unidentified seal species and 17 individuals within the seal/ small cetacean group recorded through the 24 survey dates, a proportion of which could be harbour seal (although the majority are expected to be grey seal).

789. Due to the low number of harbour seal sightings, absolute density and abundance estimates were not possible to derive from the site-specific surveys.

790. The harbour seal density estimates for North Falls have been calculated from the latest seal at sea maps produced by Sea Mammal Research Unit (SMRU) (Carter et al., 2022), based on the 5km x 5km grids that overlap with each area (see the PEIR Appendix 12.1, Volume III), and using the density data for The Wash and North Norfolk Coast SAC (Figure 6.5). This effectively apportions the potential for effect to only those seals that are affected that are associated with the SAC itself.

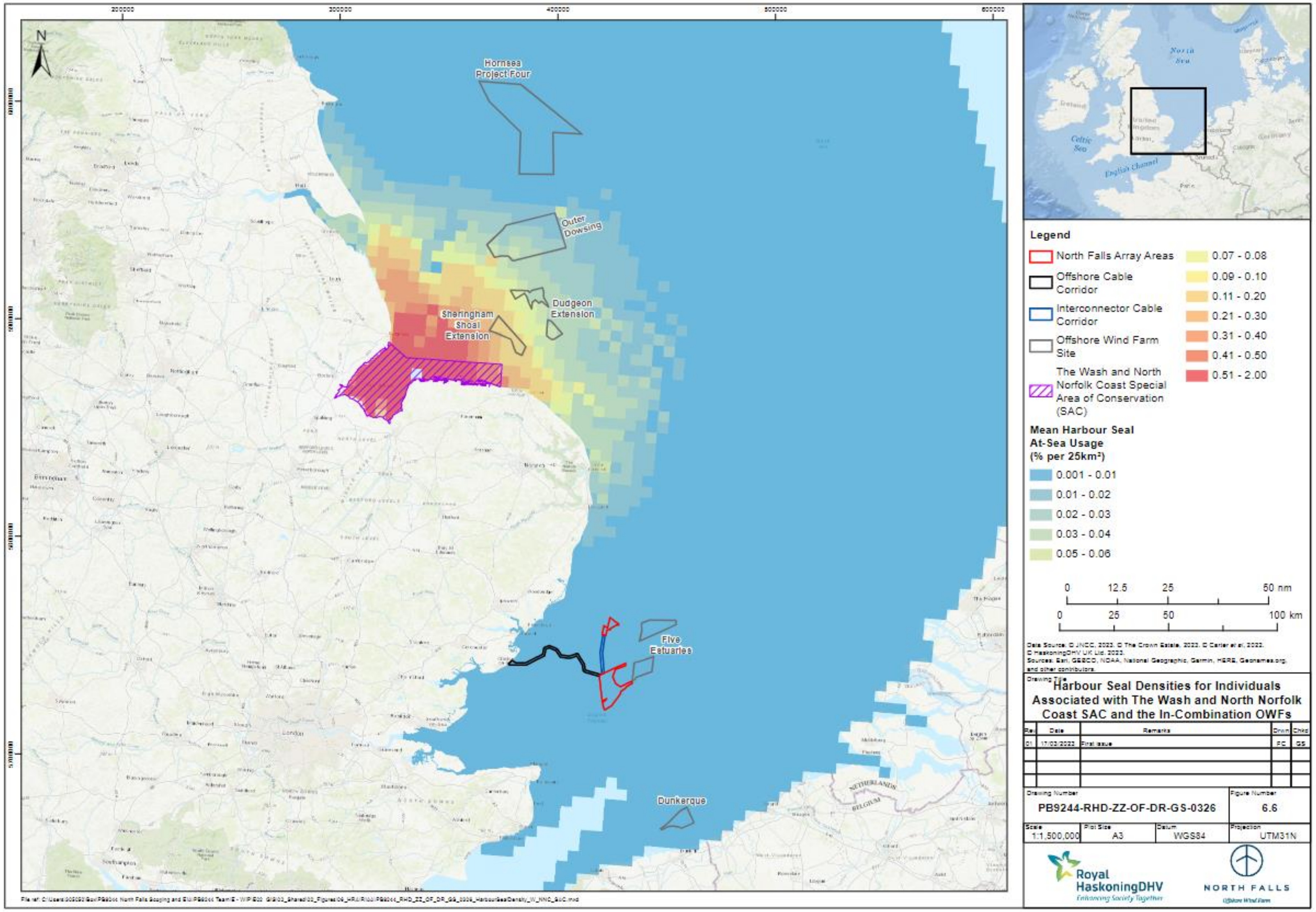

Figure 6.5 Harbour seal at-sea mean densities for those individuals associated with The Wash and North Norfolk Coast SAC

791. The total harbour seal population in the British Isles, at sea, is approximately 40,600 individuals, based on the corrected values and most recent haul-out counts for the UK (SCOS, 2021). The total at-sea harbour seal population for The Wash has been estimated as 3,258, based on the total population of harbour seal of this SAC (provided in Table 6.71 below), and calculating against a correction factor of 0.8236 (Russell et al., 2015; Carter *et al.,* 2020) to take account of those individuals at sea only. This is the population estimate used with the Carter et al. (2022) data to calculate density estimates for North Falls.

792. The mean at sea relative density estimates of harbour seal for North Falls, and all offshore export cables areas, based on the SAC specific densities from Carter et al. (2022), are:

- 0.00002 individuals per km^2 for the south array area;
- 0.0001 individuals per km^2 for the north array area;
- 0.00005 individuals per km^2 for the total area areas; and
- 0.0008 individuals per km^2 for the offshore export cables.

793. The Wash and North Norfolk Coast SAC population has been corrected to take account of the number of seals not available to count during the surveys. Approximately 0.72 harbour seals (Lonergan et al., 2013) are available to count within the August surveys (i.e. are hauled-out), and therefore this has been used as a correction factor, to derive the total harbour seal SAC population (Table 6.71).

Table 6.71 Harbour seal counts and population estimates

Population area	Harbour seal haul-out count	Source of haul-out count data	Correction factor for seals not available to count	Harbour seal SAC population
Total SAC population	2,848	-	0.72	3,946

794. There are indications of a current decline in the numbers of harbour seal in The Wash. The assessments are based on the current harbour seal counts at the time of writing, however any assessments will be based on the latest harbour seal counts at that time to take account of any changes.

6.4.2 Conservation objectives

795. The Conservation Objectives (Natural England, 2018c) are “To ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats and habitats of qualifying species
- The structure and function (including typical species) of qualifying natural habitats
- The structure and function of the habitats of qualifying species

- The supporting processes on which qualifying natural habitats and habitats of qualifying species rely
- The populations of qualifying species, and,
- The distribution of qualifying species within the site."

796. For harbour seal within The Wash and North Norfolk Coast SAC, the specific targets are to;

- Maintain the population size within the site;
- Maintain the reproductive and recruitment capability of the species;
- Maintain the presence and spatial distribution of the species and their ability to undertake key life stage and behaviours;
- Maintain connectivity of the habitat within sites and the wider environment to allow movement of migratory species;
- Restrict the introduction and spread of non-native species and pathogens, and their impacts;
- Maintain the extent and spatial distribution of the following supporting habitats; foraging and haulout sites;
- Maintain the abundance of preferred food items required by the species;
- Maintain the natural physio-chemical properties of the water;
- Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement is not significantly altered or constrained;
- Restrict aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels;
- Maintain water quality to mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features avoiding deterioration from existing levels; and
- Maintain natural levels of turbidity (e.g. suspended concentrations of sediment, plankton and other material) in areas where this species is, or could be present.

797. Due to the decline in the harbour seal population within The Wash and North Norfolk Coast SAC, Natural England are in the process of updating the Conservation Objectives of the SAC. As these are not yet finalised, the assessments are based on the current Conservation Objectives as noted above, however, if the updated Conservation Objectives are in place at the time of RIAA finalisation prior to DCO submission, the assessments will be amended accordingly.

6.4.3 Shadow appropriate assessment

798. For the assessments for The Wash and North Norfolk Coast SAC, the potential for effects is considered in relation to the SAC Conservation Objectives for harbour seal (Table 6.72).

Table 6.72 Potential Effects of North Falls in Relation to the Conservation Objectives of The Wash and North Norfolk Coast SAC for Harbour Seal

Conservation Objective for harbour seal	Potential Effect
The extent and distribution of qualifying natural habitats and habitats of qualifying species.	No potential LSE. There will be no significant change to the extent and distribution of the habitats of qualifying species in the SAC.
The structure and function (including typical species) of qualifying natural habitats.	No potential LSE. There will be no significant change to the structure and function (including typical species) of qualifying natural habitats.
The structure and function of the habitats of qualifying species.	No potential LSE. There will be no significant change to the structure and function) of the habitats of the qualifying species.
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.	No potential LSE. There will be no significant change to the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely.
The populations of qualifying species.	Increased collision risk with vessels may cause a potential LSE which will be considered further.
The distribution of qualifying species within the site.	No potential LSE. There will be no significant change to the distribution of qualifying species within the site. However, significant disturbance and displacement as a result of increased underwater noise levels have the potential to have an effect on the seals foraging at sea and will be considered further.

6.4.3.1 Potential effects during construction

799. Potential effects during construction may arise through disturbance from activities during the installation of offshore infrastructure. Underwater noise during piling, as well as disturbance associated with underwater noise from other construction activities and the presence of vessels offshore, are considered. Potential displacement from important habitat areas and impacts on prey species are also considered.

800. The potential effects during construction assessed for marine mammals are:

- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during piling, and due to ADD activation prior to piling;
  - Permanent auditory injury (PTS) due to impact piling.
  - Disturbance due to impact piling.
  - Disturbance due to ADD activation prior to piling.
- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during other construction activities, including seabed preparations, rock placement and cable installation;
  - Permanent auditory injury (PTS) due to other construction activities.
  - Disturbance due to other construction activities.
- Impacts resulting from the deployment of construction vessels:

    - Underwater noise and disturbance from construction vessels;
        - Permanent auditory injury (PTS) due to construction vessels.
        - Disturbance due to construction vessels.
    - Vessel interaction (collision risk).
- Barrier effects as a result of underwater noise;
- Changes to water quality; and
- Changes to prey resource.

801. The potential for disturbance at seal haul-out sites has not been assessed for The Wash and North Norfolk Coast SAC. Due to the distance between North Falls and the SAC, there is no potential for an effect to the haul-out sites within the site.

6.4.3.1.1 Impact 1: Effects of underwater noise associated with piling

802. A range of foundation options are being considered for North Falls, including monopiles, jackets (with pin piles), suction buckets for both monopiles and jacket pin piles, and gravity-based for both monopiles and jacket pin piles. Of these, monopiles and jackets (with pin piles) may require piling. As a worst case scenario for underwater noise, it has been assumed that all foundations could be piled, although drive-drill-drive installation may be used.

803. Impact piling is a source of high-level underwater noise, which can cause both physiological (e.g. lethal, physical injury and auditory injury) and behavioural (e.g. disturbance and masking of communication) effects on marine mammals.

804. Should a seal be very close to the source, the high peak pressure sound levels have the potential to cause death or physical injury, with any severe injury potentially leading to death, if no adequate mitigation is in place. High exposure levels from underwater noise sources can cause auditory injury or hearing impairment, taking the form of a permanent loss of hearing sensitivity (PTS).

805. The underwater noise modelling was based on the worst-case scenarios for monopiles and pin-piles as shown in Section 6.2.3.1.1.

Impact 1a: Permanent auditory injury (PTS) due to impact piling

806. Any PTS would be permanent, and harbour seal within the potential impact area are considered to have very limited capacity to avoid such effects, and unable to recover from the effects.

807. PTS can occur instantaneously from acute exposure to high noise levels, such as single strike (SPL_{peak}) of the maximum hammer energy applied during piling. PTS can also occur as a result of prolonged exposure to increased noise levels, such as during the duration of pile installation (SEL_{cum}).

PTS from a single strike

808. The underwater noise modelling results (see PEIR Appendix 12.2 (Volume III) for details) show the predicted effect ranges and areas for PTS from a single strike of the maximum hammer energy for the worst case location. For harbour seal the potential effect range for PTS is 60m (0.01km^2) for monopiles (6,000kJ) and <50m (<0.01km^2) for jacket pin piling.

809. An assessment of the maximum number of individuals that could be at risk of instantaneous PTS, due to a single strike at the maximum hammer energy, for monopiles is 0.000001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.00000003% of the SAC population), based on the north array area density estimate of 0.0001/km^2. For jacket pin piles the assessment of effect shows 0.000001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.00000003% of the SAC population).

PTS from cumulative exposure

810. The SEL_{cum} is a measure of the total received noise over the whole piling operation. The SEL_{cum} range indicates the distance from the piling location that if the receptor were to start fleeing in a straight line from the noise source starting at a range closer than the modelled range it would receive a noise exposure in excess of the criteria threshold, and if the receptor were to start fleeing from a range further than the modelled range it would receive a noise exposure below the criteria threshold.

811. The underwater noise modelling results showed the predicted effect ranges and areas for PTS due to the cumulative exposure of monopiles and jacket pin piles at the worst case location. The potential effect range for PTS for one monopile, two sequential monopiles, one jacket pin pile and four sequential jacket pin piles were <100m (<0.010km^2). The potential cumulative effect ranges are the same for either one or two sequential monopiles, or for one or four sequential jacket pin piles.

812. It is important to note that assessment for PTS from cumulative exposure is highly precautionary. There is a lot of variation in the potential effect ranges for SEL_{cum} at each location and between locations.

813. Assessments for two sequential monopiles and four sequential pin piles in a 24 hour period are provided, as the worst case. For harbour seals, up to 0.00001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0000003% of the SAC population) based on the north array area density estimate of 0.0001/km^2.

PTS from cumulative exposure from multiple piling locations

814. The simultaneous piling scenario assumes that animals are within potential effect ranges for a much longer period (i.e. they would be travelling from one pile location to another which piling is ongoing), and therefore cumulative effect ranges are much larger than for the cumulative exposure ranges of one pile at a time.

815. The potential effect ranges are not possible to model under this scenario, as there are two starting points for receptors, and it is not possible to determine the potential range at which they need to be in order to not be at risk of effect. Therefore, the following assessment is based on the potential areas of effect only.

816. Where the potential effect areas are not large enough to interact with each other (i.e. they do not meet), the results for the respective locations and scenarios are used (the results of the modelling for the South and North locations are used to inform the assessment, to align with the modelling locations used for the simultaneous modelling.

817. The underwater noise modelling results show the predicted effect ranges and areas for PTS due to the cumulative exposure of simultaneous monopiles and jacket pin piles at the North and South modelling locations. These locations were chosen as the have the potential for the largest 'spread' in terms of underwater noise propagation (as they are the two furthest apart locations). The modelling includes two monopiles being installed sequentially at each location at the same time, and four jacket pin piles being installed sequentially at each location at the same time.

818. For harbour seal the potential effect areas for PTS due to cumulative exposure of simultaneous pile installations are:

- For multiple sequential pile installations in a 24 hour period (for the North and South modelling locations together)
  - Two sequential monopiles at the North location and two sequential monopile at the South location are:
    - North = <0.1km^2
    - South = <0.1km^2
    - **Total together = <0.2km^2**
  - Four sequential jacket pin piles at the North location and four sequential jacket pin piles at the South location are
    - North = <0.1km^2
    - South = <0.1km^2
    - **Total together = <0.2km^2**
- Multiple simultaneous pile installations in a 24 hour period (one at the North and one at the South modelling location)
  - Multiple simultaneous monopiles (two sequential monopiles at each location, at the same time) have no interaction.
  - Multiple simultaneous jacket pin piles (four sequential jacket pin piles at each location, at the same time) have no interaction.

819. An assessment of the maximum number of individuals that could be at risk of cumulative PTS, for simultaneous monopiles and jacket pin piles for harbour seal indicated an effect for up to 0.00002 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0000005% of the SAC population) based on the north array area density estimate of 0.0001/km^2.

Summary for Impact 1a

820. Assessments have indicated there would be no adverse effect of PTS from piling on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

Impact 1b: Disturbance effects due to impact piling

821. The range of possible behavioural reactions that may occur as a result of exposure to noise include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour,

temporary or permanent habitat abandonment and, in severe cases, panic, or stranding, sometimes resulting in injury or death (Southall et al., 2007).

822. There are currently no agreed thresholds or criteria for the behavioural response and disturbance of marine mammals, therefore it is not possible to conduct underwater noise modelling to predict impact ranges.

823. Disturbance from construction activities (including piling) may have behavioural consequences on marine mammals in the study area, including reduced time spent foraging at sea as animals move away from sources of noise, displacement from vessels, etc. Repeated disruptions can have cumulative negative effects on the bioenergetic budget of marine species, with the potential for long-term effects on survival and reproductive rates (Christiansen et al., 2013).

824. Hastie et al. (2021) studied the change in foraging behaviour of grey seal when exposed to underwater noise. A high density and low density area of prey was present within an experimental pool, and speakers were located at each prey patch. During the control periods, seals would forage mainly at the high-density patch, but also at the low-density patch for a smaller proportion of time. When the seals were exposed to noise at the low density patch, there was a reduction in foraging of 16-28%, however, when seals were exposed to noise at the high density prey patch, there was no change in foraging in comparison to control periods (Hastie et al., 2021). This indicates that seals would choose to remain at a noisy environment, if there were good prey resources at the same location (Hastie et al., 2021).

825. Harbour seal exhibit alternate periods of foraging and resting at haul out sites (during which limited, or no feeding occurs). Prolonged fasting also occurs in these species during annual breeding and moult, when there are marked seasonal changes in body condition (Rosen and Renouf, 1997; Bäcklin et al., 2011). Although adult seals may be relatively robust to short term (weeks rather than days) changes in prey resources, young and small individuals have a more sensitive energy balance. This is exhibited through effects of mass dependent survival (Harding et al., 2005).

826. Russell et al (2016) showed that harbour seal are present in significantly reduced number up to a distance of 25km during piling (or a disturbance area of 1,963.5km^2) (Russell et al., 2016). This range has been used to determine the number of harbour seal that may be disturbed during piling at North Falls.

827. The assessment of the potential for disturbance to harbour seal based on a disturbance range of 25km for both monopiles and jacket pin piles indicated:

- For a single piling event - 0.20 harbour seal associated with The Wash and North Norfolk Coast SAC (0.005% of the SAC population) based on the array area density estimate of 0.0001/km^2).
- For two simultaneous piling events - 0.39 harbour seal associated with The Wash and North Norfolk Coast SAC (0.01% of the SAC population) based on the array area density estimate of 0.0001/km^2).

828. For disturbance based on the known effect ranges for harbour seals, there would be no adverse effect on the integrity of The Wash and North Norfolk

Coast SAC in relation to the conservation objectives for harbour seal, for either monopiles or jacket pin piles.

Impact 1c: Disturbance effects due to ADD activation

829. The assessments of the potential disturbance during any ADD activation is indicative only, as the final requirements for mitigation in the MMMP will be determined prior to construction.

830. Mitigation to reduce the risk of PTS could include activation of ADDs prior to the soft-start commencing. The period of time that an ADD is required to be activated for is dependent on the potential PTS ranges for each species, and their known swim speeds, as used within the underwater noise modelling.

831. During 10 minutes of ADD activation, harbour seal would move at least 0.9km from the ADD location (based on a precautionary marine mammal swimming speed of 1.5m/s; Otani et al., 2000), resulting in a potential disturbance area of 2.55km^2. This is further than the instantaneous PTS range for monopiles predicted for harbour seal.

832. For 10 minutes of ADD activation, up to 0.0003 harbour seal associated with The Wash and North Norfolk Coast SAC (0.00001% of the SAC population) would be disturbed based on the array area density estimate of 0.0001/km^2.

833. The ADD activation would ensure marine mammals are beyond the maximum impact range for instantaneous PTS due to a single strike of the maximum hammer energy for both monopiles and jacket pin piles. ADD activation prior to the soft-start would also reduce the number of marine mammals at risk of PTS from cumulative exposure.

834. There would be no adverse effects for disturbance based on the known effect ranges for marine mammals for harbour seal and the integrity of The Wash and North Norfolk Coast SAC, for either monopiles or jacket pin piles.

6.4.3.1.2 Impact 2: Effects from underwater noise associated with other construction activities

835. Potential sources of underwater noise during construction activities, other than piling, include seabed preparation, dredging, rock placement, trenching and cable installation.

836. Dredging/cable installation activities have the potential to generate underwater noise at sound levels and frequencies for sufficient durations to disturb marine mammals. Reviews of published sources of underwater noise during dredging activity (e.g. Thomsen et al., 2006; Theobald et al., 2011; Todd et al., 2014), indicate that the sound levels that marine mammals may be exposed to during dredging activities are typically below permanent auditory injury thresholds (PTS) exposure criteria (as defined in Southall et al., 2019). Therefore, the potential risk of any auditory injury in marine mammals as a result of dredging activity is highly unlikely.

837. Underwater noise as a result of dredging activity/cable installation, also has the potential to disturb marine mammals (Pirotta et al., 2013). Therefore, there is the potential for short, perhaps medium-term behavioural reactions and disturbance to marine mammals in the area during dredging / cable installation activity. Marine mammals may exhibit varying behavioural reactions intensities as a result of exposure to noise (Southall et al., 2007).

838. The noise levels produced by dredging activity/cable installation, could overlap with the hearing sensitives and communication frequencies used by marine mammals (Todd et al., 2014), and therefore have the potential to impact marine mammals present in the area.

839. The potential for disturbance that could result from underwater noise during other construction activities, including cable laying and protection would be temporary in nature, not consistent throughout the offshore construction period, and would be limited to only part of the overall construction period and area at any one time.

840. The duration for the offshore construction period, including piling and offshore export cable installation, is approximately three years. However, construction activities would not be underway constantly throughout this period. Further details on the construction schedule are provided in Chapter 5 Project Description (Volume I).

841. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during noisy activities (PEIR Appendix 12.2, Volume III**)** and determine the potential effects on marine mammals.

Impact 2a: Permanent auditory injury (PTS) due to other construction activities

842. The underwater noise modelling results show the predicted effect ranges and areas for PTS from the cumulative exposure of other construction activities. For SEL_{cum} calculations, the duration of the noise is also considered, with all sources operating for a worst case of 12-hours in a day. The predicted effect ranges for cumulative PTS for other construction activities on harbour seals indicated <100m (0.031km^2).

843. The results of the underwater noise modelling do not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

844. The results of the underwater noise modelling indicate that harbour seal would have to be <100m (precautionary maximum range) from the continuous noise source for 12 hours, to be exposed to noise levels that could induce PTS. It should be noted that the predicted impact ranges are the distances which represent the ‘onset’ stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

845. An assessment of the maximum number of individuals that could be at risk of PTS, due to other construction activities, for harbour seal is:

- 0.000003 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0000001% of the SAC population) based on the north array area density estimate of 0.0001/km^2; or
- 0.00003 harbour seal associated with The Wash and North Norfolk Coast SAC (0.000001% of the SAC population) based on the cable corridor areas density estimate of 0.0008/km^2.

846. There is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore export cable or interconnector corridors, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been undertaken.

847. The predicted effect areas for cumulative PTS, for all four other construction activities taking place at the same time is $0.126km^2$ for harbour seal. The maximum number of individuals that could be at risk of PTS, due to all other construction activities undertaken at the same time is:

- 0.00001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0000003% of the SAC population) based on the north array area density estimate of $0.0001/km^2$; or
- 0.0001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.000003% of the SAC population) based on the cable corridor areas density estimate of $0.0008/km^2$.

Impact 2b: Disturbance effects due to other construction activities

848. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

849. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance impact on marine mammals.

850. There is limited data on the potential for a behavioural response or disturbance from other construction activities (or other continuous noise sources).

851. In 2012, 25 harbour seal from The Wash were tagged, as well as a further 10 from the Thames (Russell, 2016). Of those, 24 of the tags were in place for sufficient time to determine key foraging areas of harbour seal in the southern North Sea. The results of this study show foraging activity of harbour seal off the coast off Norfolk (Russell, 2016). The results of this tagging study show foraging activity within Sheringham Shoal OWF which was undergoing construction, with turbine installation undertaken from 2011 to 2012, and cabling works from 2010 to 2012. This indicates that harbour seal will still undertake foraging activity during wind farm construction activities.

852. A review of various studies was used to determine the maximum potential disturbance range for other construction activities and vessels. During the construction of two Scottish OWFs (Beatrice OWF and Moray East OWF), Benhemma-Le Gall et al. (2021), reported a 4km ($50.3km^2$) reduction in harbour porpoise presence and this has been used as the disturbance range for other construction activities, including vessels. As harbour porpoise are the most sensitive marine mammal species, this 4km potential disturbance range has been used for harbour seal as a worst case, due to the absence of any other data to inform an assessment.

853. The maximum number of individuals that could be at risk of disturbance due to other construction activities based on the 4km potential disturbance range is:

- 0.005 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0001% of the SAC population) based on the north array area density estimate of 0.0001/km^2; or
- 0.04 harbour seal associated with The Wash and North Norfolk Coast SAC (0.001% of the SAC population) based on the cable corridor areas density estimate of 0.0008/km^2.

854. This is a precautionary approach as it is unlikely that harbour seal would react in the same manner as harbour porpoise to the other construction activities that are expected to be taking place in the offshore project area.

855. As noted above, there is the potential that more than one of these other construction activities could be underway at either array area, or within the offshore export cable or interconnector corridors, at the same time. As a worst case and unlikely scenario, an assessment for all four activities being undertaken simultaneously has also been undertaken.

856. Based on a 4km potential disturbance range, and up to four other construction activities taking place at the same time, there is the potential for a simultaneous disturbance effect are of 201.06km^2 for all marine mammal species. As noted above, this assumes that the disturbance would only affect the area around the vessel at the time of the activity taking place, and that marine mammals would return to the disturbed area once the activity had either completed or transited to a new location.

857. An assessment of the maximum number of harbour seal individuals that could be at risk of disturbance, due to all other construction activities undertaken at the same time is:

- 0.02 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0005% of the SAC population) based on the array area density estimate of 0.0001/km^2; or
- 0.16 harbour seal associated with The Wash and North Norfolk Coast SAC (0.004% of the SAC population) based on the cable corridor areas density estimate of 0.0008/km^2.

Summary for impact 2

858. For permanent changes in hearing sensitivity (PTS) and potential disturbance due to other construction activities (without any mitigation), there would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.1.3 Impact 3: Effects from underwater noise and disturbance associated with construction vessels

859. During the construction phase there will be an increase in the number of vessels in the offshore project area; this is estimated to be up to a total of 35 vessels at any one time. The number, type and size of vessels will vary depending on the activities taking place at any one time.

860. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of

underwater noise from vessels during construction will be within the array areas and offshore cable corridor.

861. The types of vessels that were recorded in the shipping and navigation study area (of the array sites plus 10 nm buffer, and the cable corridors plus 2 nm buffer) include fishing vessels, military vessels, dredgers, tugs, passenger vessels, cargo ships, tankers, vessels associated with either oil and gas or OWF projects, or recreational vessels. In total, an average of 151 vessels per day were recorded in the shipping and navigation study area in winter, and 167 per day in summer. The most common vessel in the study area was cargo vessels, accounting for more than half of all vessel traffic, while tankers accounted for 20% of all vessels.

862. With a peak of 35 vessels expected to be on site at any one time during the construction of North Falls, there will be approximately a 23% increase in the daily vessel presence during the winter period, and approximately a 21% increase during the summer period.

863. Noise measurements indicate that the most intense sound emissions from a cargo ship are typically low frequencies, up to and including 1kHz (Robinson et al., 2011) travelling at modest speed (between 8 and 16 knots) (Theobald et al., 2011). Underwater noise from construction vessels of a similar size also has the potential to disturb marine mammals in the short-term, in areas of increased vessel traffic, but are unlikely to produce any permanent auditory injury (PTS) (Pirotta et al., 2013).

864. The vessels will be slow moving (or stationary), and most noise emitted is likely to be of a lower frequency. Noise levels reported by Malme et al. (1989) and Richardson et al. (1995) for transiting large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. The potential risk of permanent auditory injury (PTS) in marine mammals as a result of vessel activity is highly unlikely, as the sound levels that are produced by vessels is well below the threshold for permanent injury (Southall et al., 2019).

865. Thomsen et al. (2006) reviewed the effects of ship noise on seal species and concluded that ship noise around 0.25kHz could be detected at distances of 1km; and ship noise around 2kHz could be detected at around 3km.

866. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise due to vessel presence (PEIR Appendix 12.2, Volume III) and determine the potential effects on harbour seal.

Impact 3a: Permanent auditory injury (PTS) due to construction vessels

PTS due to construction related vessels (single vessel)

867. The underwater noise modelling results show the predicted effect ranges and areas for PTS from the cumulative exposure of vessels within the site. For SEL_{cum} calculations, the duration of the noise is also considered, with noise present for a worst case of 24-hours in a day.

868. The results of the underwater noise modelling do not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

869. The results of the underwater noise modelling indicate that harbour seal would have to be <100m (precautionary maximum range) from the continuous noise source for 24 hours, to be exposed to noise levels that could induce PTS. It is therefore highly unlikely that any marine mammal would be at risk of PTS due to vessel noise. It should be noted that the predicted impact ranges are the distances which represent the ‘onset’ stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

870. An assessment of the maximum number of individuals that could be at risk of PTS, due to construction vessels, is:

- 0.000003 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0000001% of the SAC population) based on the array area density estimate of 0.0001/km^2; or
- 0.00003 harbour seal associated with The Wash and North Norfolk Coast SAC (0.000001% of the SAC population) based on the cable corridor areas density estimate of 0.0008/km^2.

871. There is the potential that up to 35 vessels may be present in the North Falls site at any one time during construction. As a worst case and unlikely scenario, an assessment for all 35 vessels has also been undertaken.

872. The predicted effect areas for cumulative PTS for the maximum construction vessels at any one time, of 35 vessels, is 1.1km^2 for harbour seals.

873. An assessment of the maximum number of individuals that could be at risk of PTS, due to the maximum number of construction vessels at any one time is:

- 0.0001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.000003% of the SAC population) based on the array area density estimate of 0.0001/km^2; or
- 0.009 harbour seal associated with The Wash and North Norfolk Coast SAC (0.00002% of the SAC population) based on the cable corridor areas density estimate of 0.0008/km^2.

Impact 3b: Disturbance effects due to construction vessels

874. Seals vary in their reaction to vessels depending on vessel type and proximity to haul out sites; however, disturbance (flushing behaviour) has been demonstrated at haul-out sites in the UK up to 200m away if there are pups present (Cates et al., 2017). Land-based disturbance has been shown to cause higher levels of disturbance compared to marine sources, and smaller, quiet vessels like kayaks can cause the highest levels of flushing behaviour (Bonner, 2021). In areas of high vessel traffic, there are habituation effects and disturbance behaviour is generally reduced (Strong et al., 2010). A 2019 study on harbour seals in Scotland found that 30 minutes after a disturbance event, seals return to 52% pre-disturbance levels at haul-out sites and 94% four hours after disturbance (Paterson, 2019).

875. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any effects from underwater noise as a result of construction activities, other than

piling, will be both localised and temporary. Therefore, there is unlikely to be the potential for any significant disturbance for harbour seals.

876. There is limited data on the potential for a behavioural response or disturbance from vessel noise. Based on the studies by Brandt et al. (2018) and Benhemma-Le Gall et al. (2021) that found that harbour porpoise could be disturbed up to 2km from construction vessels. As harbour porpoise are the most sensitive marine mammal species, this 2km (12.57km^2) potential disturbance range has been used for harbour seal as a worst case, due to the absence of any other data to inform an assessment.

877. An assessment of the maximum number of harbour seal individuals that could be at disturbed due to the maximum number of construction vessels at any one results in:

- 0.001 harbour seal associated with The Wash and North Norfolk Coast SAC (0.00003% of the SAC population) based on the array area density estimate of 0.0001/km^2; or
- 0.01 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0002% of the SAC population) based on the cable corridor areas density estimate of 0.0008/km^2.

878. Construction vessel activity may generate underwater noise at sound levels and frequencies for sufficient durations to disturb marine mammals. Whilst the main focus of concern remains on the loudest noise sources such as impact piling, dredging etc., intense vessel activity during construction may also alter the acoustic habitat and disturb marine mammal species (Merchant et al., 2014). During the periods when piling is underway, vessel noise is unlikely to add an additional impact to those assessed for piling, as the vessels and vessel noise would be within the maximum impact areas assessed.

879. During baseline surveys (see the PEIR Chapter 15 Shipping and Navigation), the average recorded number of vessels per day in the summer was 167 (predominantly cargo). During the construction phase there may be an increase in the number of vessels in the area, however, this is likely to be offset by construction vessels/activity displacing existing vessel traffic as commercial vessels tend to deviate to avoid construction/decommissioning areas. The number, type and size of vessels will vary depending on the activities taking place at any one time. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the offshore project area only.

880. Jones et al. (2017) produced usage maps characterising densities of grey and harbour seals and ships around the British Isles, which were used to produce risk maps of seal co-occurrence with shipping traffic. The analysis indicates that rates of co-occurrence were highest within 50km of the coast, close to seal haul-outs. When considering exposure to shipping traffic in isolation, the study found no evidence relating to declining seal population trajectories with high levels of co-occurrence between seals and vessels. For example, in areas of east England where the harbour seal population is increasing there are high intensities of vessels (Duck and Morris, 2016; Jones et al., 2017).

881. If the behavioural response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed, and therefore any impacts from underwater noise as a result of construction vessels will be both localised and temporary.

Summary for impact 3

882. For permanent changes in hearing sensitivity (PTS) and potential for disturbance due to construction vessels, there would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.1.4 Impact 4: Barrier effects from underwater noise during construction

883. Underwater noise during construction could have the potential to create a barrier effect, preventing movement or migration of marine mammals between important feeding and / or breeding areas, or potentially increasing swimming distances if marine mammals avoid the site and go around it. However, the offshore project area not located on any known migration routes for marine mammals.

884. The array areas are located 22.5km from the coast at closest point. The nearest seal haul-out site at Gunfleet Sands, approximately 2.8km from the offshore cable corridor at its closest point. Note that this is a tidal haul-out site, and is only exposed at low tide, so is not a haul-out site that would be used for pupping.

885. Telemetry studies and the relatively low seal at sea usage (Carter et al., 2022) in and around the offshore project area do not indicate any regular seal foraging routes through the sites. Russell (2016 have shown that harbour seal will still undertake foraging activity during wind farm construction activities.

886. A tagging study was undertaken for harbour seals within the outer Thames estuary, through the Thames Harbour Seal Conservation Project (Barker et al., 2014). This study included the tagging of harbour seals in 2012. The results of this tagging study were used to define foraging areas of harbour seal within the outer Thames area. The activity of the seals while tagged was used to identify key foraging areas, with five such areas being found. These were all located within 4.5km of the nearest haul-out site (Barker et al., 2014). These foraging locations were plotted against the OWFs in the area (at the time of the study), which shows that GGOW (immediately to the east of North Falls) is not located near to any of the five identified key foraging areas (Barker et al., 2014), with the closest being north east Buxey Sand, at more than 10km from the offshore cable corridor, and 47km from the array areas.

887. The greatest potential barrier effect for marine mammals could be from underwater noise during piling. Piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles, and if installed in groups there could be time periods when piling is not taking place as piles are brought out to the site. There will also be potential delays for weather or other technical issues.

888. There is unlikely to be the potential for any barrier effects from underwater noise for other construction activities and vessels, as it is predicted that marine mammals will return once the activity has been completed, and therefore any effects from underwater noise as a result of construction activities other than piling noise will be both localised and temporary. Therefore, there is unlikely to

be the potential for any barrier effects that could significantly restrict the movements of marine mammals.

889. Harbour seal have foraging ranges of up to 273km (Carter et al., 2022). Therefore, if there are any potential barrier effects from underwater noise, marine mammals would be able to compensate by travelling to other foraging areas within their range.

890. There is unlikely to be any significant long-term impacts from any barrier effects, as any areas affected would be relatively small in comparison to the range of harbour seals and would not be continuous throughout the offshore construction period. It is therefore considered that, for barrier effects as a result of underwater noise, there would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.1.5 Impact 5: Increased risk of collision with vessels during construction

891. During offshore construction, there will be an increase in vessel traffic within the offshore project area. However, it is anticipated that vessels would follow an established shipping route to the relevant ports in order to minimise vessel traffic in the wider area.

892. Seals in and around the offshore project area and in the wider southern North Sea area would typically be habituated to the presence of vessels (given the existing levels of marine traffic, see Chapter 15 Shipping and Navigation) and would be able to detect and avoid vessels.

893. However, vessel strikes are known to occur, possibly due to distraction whilst foraging and socially interacting, or due to the marine mammals' inquisitive nature (Wilson et al., 2007). Therefore, increased vessel movements, especially those outside recognised vessel routes, can pose an increased risk of vessel collision to marine mammals. Studies have shown that larger vessels are more likely to cause the most severe or lethal injuries, with vessels over 80m in length causing the most damage to marine mammals (Laist et al., 2001). Vessels travelling at high speeds are considered to be more likely to collide with marine mammals, and those travelling at speeds below 10 knots would rarely cause any serious injury (Laist et al., 2001).

894. There is currently limited information on the collision risk of marine mammals in the southern North Sea. To estimate the potential collision risk of vessels associated with North Falls during construction, the potential risk rate per vessel has been calculated for harbour seals, which is then used to calculate the total risk to harbour seals due to the presence of an additional 35 vessels at any one time during construction (See PEIR Chapter 12 Volume I, Section 12.6.1.5). The collision risk has been estimated by using data from the SMASS.

895. SMASS record and investigate all marine mammal strandings reported to them in Scotland. Between 2003 and 2020, 791 stranded harbour seal were investigated with a cause of death established by SMASS. A total of 13 were attributed to a physical trauma of unknown cause, and four to physical trauma following impact from a vessel. This results in a collision risk rate of 0.028.

896. To inform this assessment, the total number of harbour seals in UK waters has been compared against the total vessels present in UK waters, as well as the potential collision risk rate of each species based on the SMASS data. The total

UK populations are taken from IAMMWG (2022) for all cetacean species, and the total UK populations for seal species are taken from SCOS (2021). The total presence of vessels in UK waters is taken from the total vessel transits within the 2015 AIS data, which is the latest publicly available.

897. The assessment (See PEIR, section 12.6.1.5 and Table 12.63) predicts that 0.33 individual harbour seal may be at risk of collision (0.008% of The Wash and North Norfolk Coast SAC population)

898. This is a highly precautionary assumption, as it is unlikely that marine mammals in the offshore project area would be at increased collision risk with vessels during construction, considering the minimal number of vessel movements compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

899. In addition, vessel movements, where practicable, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. Vessel operators will use best practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever possible.

900. There would be no adverse effect for any increase in vessel collision risk during construction on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.1.6 Impact 6: Changes to water quality

901. Potential changes in water quality during construction could occur through:

- Deterioration in water quality due to an increase in suspended sediment associated with seabed preparation for the installation of foundations, array, and interconnector cables;
- Deterioration in water quality due to an increase in sediment concentrations due to drill arisings for installation of piled foundations for wind turbines and OSP;
- Deterioration in water quality due to increases in suspended sediment associated with the installation of the offshore export cable; and
- Deterioration in water quality associated with release of sediment bound contaminants.

902. North Falls are committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction activities. As a result, an outline PEMP will be developed to accompany the DCO application. The final PEMP would be agreed with the MMO prior to construction and would include, for example, measures to control accidental release of drilling fluids whilst ensuring that any chemicals used are listed on the OSPAR List of Substances Used and Discharged Offshore which are considered PLONOR (OSPAR, 2021).

903. Marine mammals often inhabit turbid environments and cetaceans utilise sonar to sense the environment around them and there is little evidence that turbidity affects cetaceans directly (Todd et al., 2014).

904. Increased turbidity is unlikely to have a direct impact on marine mammals that often inhabit naturally turbid or dark environments. This is likely because other senses are utilised, and vision is not relied upon solely.

905. Any direct impacts to marine mammals as a result of any contaminated sediment during construction activities are unlikely as any exposure is more likely to be through potential indirect impacts via prey species.

906. There would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal due to any changes in water quality during the construction of North Falls.

6.4.3.1.7 Impact 7: Changes to prey availability and habitat quality

907. The potential effects on prey species during construction can result from physical disturbance and loss of seabed habitat; increased SSC and sediment re-deposition; and underwater noise. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of these impact pathways on the relevant fish and shellfish species and concludes impacts of negligible to minor adverse significance in EIA terms.

908. During construction activities, the worst-case footprint for disturbance would be 6.1km^2, constituting only 0.000017% of the total SNS SAC area. Predominantly medium and coarse-grained sediment type were found at North Falls (see Chapter 8 Marine Geology, Oceanography and Physical Processes, Volume I), typically remaining close to the seabed and settling quickly once disturbed. The worst-case level of sediment smothering and deposition would be approximately <1mm, short-lived (minutes) and localised. Increases in suspended sediment are therefore expected to cause localised and short-term increases in SSC only and not significantly affect fish species.

909. The data and analysis in PEIR Chapter 9 Marine Water and Sediment Quality (Volume I) indicates that levels of contaminants within the North Falls offshore site are low and do not contain elevated levels to cause concern.

910. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I), provides an assessment of the potential underwater noise impacts on fish and shellfish species and predicts that impacts would be of a temporary nature (see Chapter 11, Volume I, for a detailed assessment of underwater noise impacts on fish species). Potential sources of underwater noise and vibration during construction include piling, increased vessel traffic, seabed preparation, rock placement and cable installation. Of these, piling is considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse impacts on fish.

911. Piling could have mortality/injury effects, but under a realistic fleeing animal assumption, ranges at which mortality/potential mortal injury and recoverable injury could occur would be reduced to less than 100m (see PEIR Table 11.21 to 11.34). Therefore, any effect on prey populations would be highly localised.

912. The outputs of the underwater noise modelling for the spatial worst-case scenario indicate that TTS may occur at distances up to 16km and 17km assuming a fleeing animal scenario (single pin pile and sequential pin pile installation), increasing to up to 33km and 39km when considering a stationary receptor (single monopile and sequential monopiles installation). Behavioural responses would be expected within these ranges and potentially in wider areas

depending on the hearing ability of the species under consideration (see PEIR Chapter 11 Table 11.21 to 11.34 (Volume I)). However, the potential for behavioural response does not indicate that prey would actually leave the area (and in many cases this would not be possible within the duration of a piling event).

913. It is unlikely that there would be significant changes to prey over the entire area. It is more likely that effects would be restricted to an area around the working sites. There is unlikely to be any additional displacement of harbour seals as a result of any changes in prey availability during piling as harbour seals would also be disturbed from the area.

914. PEIR Chapter 11 Fish and Shellfish Ecology (Volume I) provides an assessment of the potential changes in fishing activity by the presence of safety zones associated with the project during construction. The predicted impact would be of negligible impact given the short-term and temporary nature of the construction phase.

915. Harbour seals are considered generalist feeders, and feed on a variety of species, e.g., large gadids (Wilson & Hammond, 2019). Despite the large foraging ranges of 273 km (Carter et al., 2022), harbour seals in a study in Orkney spent the majority of time within a few kilometres off the coast (Jones et al., 2016). This is in line with a tagging study of 25 harbour seal from The Wash which mainly utilised foraging grounds off the coast of Norfolk (near SEP and DEP, Sheringham Shoal and Dudgeon OWFs) and a relatively lower level of activity at Hornsea Projects One, Two, and Four, as well as Dogger Bank A (Russell, 2016).

916. The potential impacts of physical disturbance, temporary habitat loss, increased SSC, re-mobilisation of contaminated sediment on changes in prey availability associated with the construction at North Falls would be localised and short in duration and would therefore be unlikely to affect harbour seals in The Wash and North Norfolk Coast SAC.

917. Taking into account this precautionary approach, along with the separation distance from The Wash and North Norfolk Coast SAC and no potential for any direct effect on The Wash and North Norfolk Coast SAC, there would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal as a result of any changes to prey availability during construction for North Falls.

6.4.3.2 Potential effects during O&M

918. The potential effects during O&M that have been assessed for are:

- Auditory injury and disturbance or behavioural impacts resulting from operational WTGs;
  - Permanent auditory injury (PTS).
  - Disturbance.
- Auditory injury and disturbance or behavioural impacts resulting from underwater noise during maintenance activities, including cable protection and cable reburial;
  - Permanent auditory injury (PTS).

    - Disturbance.
- Impacts resulting from the deployment of vessels:
    - Underwater noise and disturbance from vessels;
        - Permanent auditory injury (PTS).
        - Disturbance.
- Vessel interaction (collision risk).
- Barrier effects as a result of underwater noise;
- Changes to water quality; and
- Changes to prey resource and habitat quality.

6.4.3.2.1 Impact 1: Impacts from underwater noise associated with operational WTGs

919. Underwater noise modelling was undertaken by Subacoustech Environmental Ltd to estimate the noise levels likely to arise during the operational phase and determine the potential effects on marine mammals (PEIR Appendix 12.2).

Impact 1a: Permanent auditory injury (PTS) due to operational wind turbine noise

920. The underwater noise modelling results show the predicted effect ranges and areas for PTS from the cumulative exposure of operational WTGs. For SEL_{cum} calculations, the duration of the noise is also considered, with operating WTGs for a worst case of 24-hours in a day. Potential effect ranges for PTS for harbour seal is <100m (0.031km^2).

921. The results of the underwater noise modelling do not define effect ranges of <100m, and therefore, where the effect ranges are less than that, the results show effect ranges of <100m (it is possible that the actual effect ranges are therefore considerably lower).

922. It is important to note that PTS is unlikely to occur in marine mammals, as the modelling indicates that the marine mammal would have to remain <100m from a WTG for 24 hours for any potential risk of PTS.). Therefore, PTS as a result of operational WTG noise is highly unlikely. It should be noted that the predicted impact ranges are the distances which represent the ‘onset’ stage, which is the minimum exposure that could potentially lead to the start of an effect and may only be marginal. In most hearing groups, the noise levels are low enough that there is negligible risk.

923. An assessment of the maximum number of individuals that could be at risk of PTS, due to a single operational WTG, concludes that 0.000003 harbour seal associated with The Wash and North Norfolk Coast SAC (0.0000001% of the SAC population) could be affected based on the array area density estimate of 0.0001/km^2.

924. More than one WTG will be operating at the same time, and therefore an assessment of the potential for auditory injury, due to all operational WTGs, is required. There is the potential for either 72 of the smallest WTGs, or 40 of the largest WTGs to be installed for the North Falls project. The potential auditory effect ranges are the same for the range of WTGs included in the North Falls

design envelope, and therefore the worst case would be for a total of 72 operational WTGs.

925. The potential effect area for PTS is 2.26km^2 for harbour seal.

926. An assessment of the maximum number of individuals that could be at risk of PTS from all operational WTGs is 0.0002 harbour seal associated with The Wash and North Norfolk Coast SAC (0.000006% of the SAC population) based on the array area density estimate of 0.0001/km^2).

927. The indicative separation distance between WTGs would be a minimum of 0.82km to 1.685km, depending on WTG size, therefore there would be no overlap in the potential impact range of <100m (<0.1km) around each WTG.

Impact 1b: Disturbance effects due to operational wind turbine noise

928. Currently available data indicates that there is no lasting disturbance or exclusion of seals around OWF sites during operation (Diederichs et al., 2008; Lindeboom et al., 2011; Marine Scotland, 2012; McConnell et al., 2012; Russell et al., 2014; Scheidat et al., 2011; Teilmann et al., 2006; Tougaard et al., 2005, 2009a, 2009b). Data collected suggests that any behavioural responses for seal may only occur up to a few hundred metres away (Touggard et al., 2009b; McConnell et al., 2012).

929. Monitoring studies at Nysted and Rødsand have also indicated that operational activities have had no impact on regional seal populations (Teilmann et al., 2006; McConnell et al., 2012). Tagged harbour seals have been recorded within two operational OWF sites (Alpha Ventus in Germany and Sheringham Shoal in UK) with the movement of several of the seals suggesting foraging behaviour around WTGs (Russell et al., 2014).

930. Modelling of noise effects of operational OWFs suggest that harbour seals are not considered to be at risk of displacement (Marmo et al., 2013).

931. There is limited data on the potential for a behavioural response or disturbance from operational WTG noise.

Summary for impact 1

932. There would be no adverse effects for permanent changes in hearing sensitivity (PTS) and disturbance due to operational WTG noise on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.2.2 Impact 2: Impacts from underwater noise associated with O&M activities

933. Disturbance to marine mammals foraging at sea may occur as a result of displacement from vessel traffic and sources of noise, including those associated with O&M activities.

934. The potential for PTS is only likely in very close proximity to cable laying or rock placement activities, and if the marine mammal remains within close proximity for 24 hours. Therefore, it is highly unlikely for there to be any PTS due to these activities.

935. The effects from additional cable laying and protection are temporary in nature and will be limited to relatively short periods during the O&M phase. Disturbance responses are likely to occur at significantly shorter ranges than construction

noise. Any disturbance is likely to be limited to the area in and around where the actual activity is taking place. The requirements for any potential maintenance work are currently unknown, however, the work required, and impacts associated with underwater noise and disturbance from activities during O&M would be less than those during construction.

936. As there are expected to be less noisy activities during the operation phase than is required during construction (see Section 6.4.3.1.2, it is therefore likely to cause less disturbance to foraging behaviours in all species present in the study area.

937. There would be no adverse effects for permanent changes in hearing sensitivity (PTS) and potential disturbance due to these operational activities, on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.2.3 Impact 3: Impacts from underwater noise and disturbance associated with O&M vessels

938. The potential for PTS is only likely in very close proximity to vessels (<100m) and if the marine mammal remains within close proximity for 24 hours.

939. The specific requirements for any potential maintenance work are currently unknown, however the work required is likely to be similar to those activities assessed for construction. During operation, there may be up to 22 vessels in the North Falls project area at any one time, compared to the 35 vessels that would be on site during construction. Therefore, the potential effects associated with underwater noise and disturbance from vessels during O&M would be less than of those during construction (see Section 6.4.3.1.3).

940. If the response is displacement from the area, it is predicted that marine mammals will return once the activity has been completed and therefore any impacts from underwater noise as a result of O&M activities will be both localised and temporary.

941. There would be no adverse effect from operational noise from vessels on the integrity of the Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.2.4 Impact 4; Barrier effects from underwater noise during O&M

942. The indicative separation distance between turbines would be a minimum of 0.82km to 1.685km, depending on WTG size, therefore there would be no overlap in the potential impact range of <100m around each turbine and there would be adequate room for marine mammals to move through the array areas.

943. While seal species are known to transit along the coastline, there would be sufficient room for them to swim through the array through the operational period. In addition, seal species are known to be present and forage within operational wind farm areas (see Section 6.4.3.2.1), and therefore it is concluded that the presence of North Falls infrastructure would not form a barrier to any movement of marine mammal species.

944. Therefore, no barrier effects as a result of underwater noise during O&M are anticipated, and no further assessment is required.

6.4.3.2.5 Impact 5; Increased risk of collision with vessels during operation

945. It is estimated that the maximum number of vessels that could be required on site at any one-time during O&M could be up to 22, with the potential for up to 1,587 vessel round trips per year.

946. The number of marine mammals at risk of collision, per vessel, in UK waters, has been calculated as described for the construction phase (section 6.4.3.1.5), and has been used to calculate the number of each marine mammal species at risk of collision from the total number of vessel movements per year that are currently expected during the O&M phase. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk.

947. It is estimated that 0.5 harbour seal (0.013% of The Wash and North Norfolk Coast SAC population) could be at risk of collision. This is a highly precautionary assumption, as it is unlikely that harbour seal in the offshore project area would be at increased collision risk with vessels during the O&M phase, considering the minimal number of vessel movements compared to the existing number of vessel movements in the area, and that vessels within the offshore project area would be stationary for much of the time or very slow moving.

948. In addition, vessel operators will use best practice to reduce any risk of collisions with marine mammals, such as reducing the speed of vessel transits wherever possible.

949. There would be no adverse effect for any increase in vessel collision risk during O&M on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.2.6 Impact 6: Changes to water quality

950. Any effects on harbour seal would be less than those for construction (see section 6.4.3.1.6) as activities during O&M which disturb the seabed would be less frequent and more localised than during construction.

951. Therefore, there would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal as a result of any changes to water quality during O&M for North Falls.

6.4.3.2.7 Impact 7: Changes to prey availability and habitat quality

952. Taking into account the long distance between North Falls and The Wash and North Norfolk Coast SAC, there are no potential direct changes to prey resource within the SAC. Any potential changes to prey availability within or in proximity to North Falls during O&M would be less than those assessed during construction (see section 6.4.3.1.7) as there would be no piling, fewer disturbing activities etc.

953. Therefore, there would be no adverse effects on harbour seal and on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal due to changes to prey availability and habitat quality as a result of North Falls O&M.

6.4.3.3 Potential effects during decommissioning

954. Potential effects on harbour seals associated with decommissioning have not been assessed in detail, as further assessments will be carried out ahead of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements. A detailed decommissioning programme will be provided to the regulator prior to construction that will give details of the techniques to be employed and any relevant mitigation measures required.

955. Decommissioning would most likely involve the removal of the accessible installed components comprising all of the wind turbine components; part of the foundations (those above seabed level); and the sections of the infield cables close to the offshore structures, as well as sections of the offshore export cables. The process for removal of foundations is generally the reverse of the installation process. There would be no piling, and foundations may be cut to an appropriate level.

956. Potential effects during decommissioning would most likely include

- Underwater noise and disturbance from decommissioning activities;
- Underwater noise and disturbance from vessels;
- Barrier effects as a result of underwater noise;
- Increased collision risk with vessels;
- Barrier effects due to underwater noise during decommissioning;
- Changes to water quality; and
- Changes to prey resource.

957. It is not possible to provide details of the methods that will be used during decommissioning at this time. However, it is expected that the activity levels will be comparable to construction (with the exception of pile driving noise which would not occur).

958. Therefore, the potential effects on harbour seals during decommissioning would be the same or less than those assessed for construction due to the processes of decommissioning being the reverse of the installation, without the need for piling.

6.4.3.4 Potential in combination effects

959. The following in-combination assessment has been undertaken based on the CEA Screening Appendix, and Section 12.9 of PEIR Chapter 12 (Volume I).

960. The in-combination effects assessed are;

- Disturbance from underwater noise due to the following sources;
    - Piling at other OWFs;
    - Construction activities at other OWFs;
    - Geophysical surveys for OWFs;
    - Aggregate extraction and dredging;
    - Oil and gas installation projects;

    - Oil and gas seismic surveys;
    - Subsea cable and pipelines; and
    - UXO clearance.
- Barrier effects of other OWFs;
- Increased collision risk with vessels; and
- Changes in prey resource.

6.4.3.4.1 In-combination impact 1: Disturbance from underwater noise

In-combination impact 1a: Assessment of underwater noise from piling at other OWFs

961. For harbour seal associated with The Wash and North Norfolk Coast SAC, other OWFs were included in the assessment against the SAC population where the Carter *et al*. (2022) densities for the individuals associated with the SAC show presence within the 5km x 5km grid cells that overlap with the other OWF (or where there is a presence of seals within the potential disturbance area of the other OWF, e.g. within 25km for other OWFs that may be piling). Figure 6.5 shows The Wash and North Norfolk Coast SAC relative densities against all OWFs screened in for assessment.

962. Of the 17 UK and European OWFs screened in for having a construction period that could potentially overlap with the construction of the Project, five UK OWFs relevant to harbour seal effects could be piling at the same time, which is currently estimated to take place in 2028 to 2029 for North Falls;
- DEP;
- Dunkerque;
- Five Estuaries;
- Hornsea Project Four;
- Outer Dowsing; and
- SEP.

963. Of these, all are shown to have harbour seal associated with The Wash and North Norfolk Coast SAC present within the project areas.

964. This short list of OWF projects that could be piling at the same time as North Falls could change as projects develop, but this is the best available information at the time of writing, and reflects the limitations and constraints to project delivery.

965. The commitment to the mitigation agreed through the MMMP for piling would reduce the risk of physical injury or permanent auditory injury (PTS) for all marine mammals.

966. For harbour seal, the cumulative assessment is based on the reported disturbance range of harbour seal to piling:
- A potential disturbance range of 25km for seal species, with a potential disturbance area of 1,963.5km^2.

967. It should be noted that the potential areas of disturbance assume that there is no overlap in the areas of disturbance between different projects and are therefore highly conservative. For example, Five Estuaries and North Falls are within 10km of each other, SEP and DEP are approximately 10km from each other at their closest points and Outer Dowsing is less than 15km from DEP

968. The approach to the in-combination assessment for piling at OWFs is based on the potential for single piling at each wind farm at the same time as single piling at the North Falls. This approach allows for some of the OWFs not to be piling at the same time, while others could be simultaneously piling (further information is available in the PEIR Appendix 12.4, Volume III). This is considered to be the most realistic worst case scenario, as it is highly unlikely that all other wind farms would be simultaneously piling at exactly the same time as piling at North Falls.

969. It is important to note the actual duration for active piling time which could disturb marine mammals is only a very small proportion of the potential construction period, of up to approximately 76 days for North Falls, based on the estimated maximum duration to install individual piles.

970. As shown in Table 6.73 below, North Falls accounts for a very small proportion of harbour seal that may be disturbed due to OWF piling (a total of 0.1 individuals out of the 569.2 that may be disturbed in total, or 0.02% of the total seals at risk of disturbance). For the DCO application, the below assessment will be updated to take account of further information on project dates, and the assessment will be amended accordingly. In the case that a significant proportion of The Wash and North Norfolk Coast SAC harbour seal population are at risk of disturbance at that stage, population modelling would be undertaken (using PCoD) to determine whether there is the potential for a population level effect, and therefore whether there is the potential for the FCS of harbour seal to be affected.

Table 6.73 Quantitative assessment for cumulative disturbance for harbour seal from piling at other OWFs

Project	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Effect area (km^2)	Maximum number of harbour seal potentially disturbed during single piling
North Falls	0.00005	1,963.5	0.10
Dudgeon Extension	0.057	1,963.5	111.9
Dunkerque	0.00002	1,963.5	0.04
Five Estuaries	0.00001	1,963.5	0.02
Hornsea Project Four	0.0008	1,963.5	1.6
Outer Dowsing	0.030	1,963.5	58.9
Sheringham Shoal Extension	0.202	1,963.5	396.6

Project	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Effect area (km^2)	Maximum number of harbour seal potentially disturbed during single piling
Total number of seals (without NF)			569.2 569.1
Percentage of SAC population (without NF)			14.42% 14.42%

971. It is highly likely that other OWFs within the SNS SAC would require mitigation to manage the effect of in-combination disturbance, reducing the potential for significant disturbance. For the DCO application, the assessment will be updated to take account of any updates on project level mitigation commitments or marine licence conditions from the in-combination projects.

972. Should the population modelling (using PCoD, to be undertaken to inform the final RIAA) show a potential adverse effect on integrity, NFOW will seek to agree mitigation with Natural England and the MMO, in order to ensure there will be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

In-combination impact 1b: Assessment of underwater noise from construction activities (other than piling) at other OWFs

973. All OWFs with construction dates that have the potential to overlap with the construction dates for North Falls have the potential for other construction activities (such as seabed preparation, dredging, trenching, cable installation, rock placement, drilling and vessels) to occur at the same time as other construction activities at North Falls.

974. For harbour seal at The Wash and North Norfolk Coast SAC, other OWFs were included in the assessment against the SAC population where the Carter *et al*. (2022) densities for the individuals associated with SAC show presence within the 5km x 5km grid cells that overlap with the other OWF (or where there is a presence of seals within the potential disturbance area of the other OWF).

975. The only OWFs screened in for other construction activities that could have a cumulative effect with other construction activities at North Falls are Dogger Bank South East and West.

976. While the other OWFs that have been assessed under the cumulative piling assessment have the potential for overlapping construction phases, as well as those listed above, they are already assessed under a worst case of piling overlaps. As the disturbance areas for piling are significantly larger than the disturbance areas for other constriction activities, an assessment of piling at those projects would produce a much higher potential for cumulative effect than an assessment for cumulative effects with other construction activities, and they are therefore not included under the assessment for other construction activities as set out below.

977. Noise sources which could cause potential disturbance during OWF construction activities, other than pile driving, can include vessels, seabed

preparation, cable installation works and rock placement. The potential effect area, based on the worst case disturbance range of 4km, for up to four activities taking place at the same time, with an area of 201.1km^2, is used to inform the assessment.

978. Based on the projects that could have construction overlapping with North Falls, up to 0.01% of the SAC population could be temporarily disturbed (Table 6.74).

Table 6.74 Quantitative assessment for cumulative disturbance for harbour seal due to construction activities at other OWFs

Project	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.00005	1,963.5	0.1
Dogger Bank South (East and West)	0.0009	201.1	0.2
Total number of seals (without NF)			0.3 0.2
Percentage of wider reference population (without NF)			0.01% 0.005%

979. It should be noted that while the projects included within the cumulative assessment for disturbance from other OWFs constructing at the same time were done so based on the current knowledge of their possible construction or activity windows, and it is very unlikely that all activities would be taking place on the same day or in the same season, this therefore likely represents an over-precautionary and worst case estimate of the marine mammals that could be at risk of disturbance during the three year offshore construction period of North Falls.

In-combination impact 1c: Assessment of disturbance from other industries and activities

980. During the construction period for North Falls, there is the potential for disturbance to marine mammals associated with other potential noise sources, including:

- Geophysical surveys associated with other OWFs;
- Aggregate extraction and dredging;
- Oil and gas installation projects;
- Oil and gas seismic surveys;
- Subsea cable and pipelines;
- Other marine renewable projects (such as wave and tidal projects);
- Disposal sites; and
- UXO clearance.

981. For the installation of oil and gas infrastructure, marine renewable projects, and disposal sites, all potential projects have been screened out. Further

information on the CEA screening (and these results) are provided in the PEIR Appendix 12.4, Volume III.

982. It is currently not possible to estimate the number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls.

983. As outlined in the PEIR Appendix 12.4, Volume III, OWF geophysical surveys using SBPs and USBL systems have the potential to disturb marine mammals and have therefore been screened into the in-combination assessment, as a precautionary approach.

984. The potential disturbance range used in the cumulative assessment is based on the SNCB guidance for assessment for harbour porpoise.

985. Assessments for the RoC HRA for the SNS SAC (BEIS, 2020), modelled the potential for disturbance due to the use of a SBP, and results indicated that there is the potential for a possible behavioural response in harbour porpoise at up to 3.77km (44.65km^2) from the source. The current guidance for assessing the significance of noise disturbance for harbour porpoise SACs (JNCC et al., 2020) recommends the use of an EDR of 5km (78.54km^2) for geophysical surveys.

986. As a worst case, it has been assumed that all harbour seal within 5km of the survey source, a total area of 78.54km^2 could be disturbed.

987. For geophysical surveys with sub-bottom profilers, it is realistic and appropriate to base the assessments on the potential effect area around the vessel, as the potential for disturbance would be centred around the vessel at any one time. Seals would not be at risk throughout the entire area surveyed in a day, as animals would return once the vessel had passed, and the disturbance had ceased.

988. It is currently not possible to estimate the location or number of potential OWF geophysical surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. It is therefore assumed, as a worst case scenario, that there could potentially be up to two geophysical surveys in the North Sea at any one time, during construction of North Falls, with a total disturbance area of 157.1km^2.

989. As the location of the potential geophysical surveys is currently unknown, the following assessment for harbour seal uses the average density estimate across the Carter *et al.* (2022) relative density dataset for The Wash and North Norfolk Coast SAC of 0.027/km^2. This therefore assumes that there could be up to two geophysical surveys within the area in which harbour seal associated with The Wash and North Norfolk Coast SAC may be present.

Table 6.75 Quantitative assessment for cumulative disturbance of harbour seals due to up to two geophysical surveys at OWFs

Potential cumulative effect	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.00005	1,963.5	0.10

Up to two geophysical surveys	0.027	157.08	4.24
Total number of seals (without NF)			4.34 4.24
Percentage of SAC population (without NF)			0.11% 0.11%

990. Taking into account the small potential effect ranges, distances of the aggregate extraction and dredging projects from North Falls, the potential for contribution to cumulative effects is very small. Therefore, risk of PTS for harbour seal from aggregate extraction and dredging has been screened out from further consideration in the in-combination assessment.

991. As a precautionary approach, a total of six aggregate extraction and dredging projects are included in the CEA for the potential cumulative disturbance.

992. As outlined in the BEIS (2020) RoC HRA for the SNS SAC, studies have indicated that harbour porpoise may be displaced by dredging operations within 600m of the activities (Diederichs et al., 2010). As a worst case assessment, a disturbance range of 600m for harbour seal for up to six operational aggregate projects at the same time as North Falls construction This would result in a potential disturbance area of 1.13km^2 for each project, or up to 6.8km^2 for all six aggregate projects.

Table 6.76 Quantitative assessment for cumulative disturbance of harbour seal due to aggregate and dredging projects

Potential cumulative effect	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.00005	1,963.5	0.10
Aggregate and dredging projects (1.13km^2 disturbance area per project)	0.027	5.7	0.15
Total number of seals (without NF)			0.25 0.15
Percentage of SAC population (without NF)			0.01% 0.004%

993. It is currently not possible to estimate the number of potential oil and gas seismic surveys that could be undertaken at the same time as construction and potential piling activity at North Falls. Therefore, it has been assumed that at any one time, up to two seismic surveys could be taking place at the same time.

994. This assessment for the potential disturbance due to oil and gas seismic surveys is based on the following:

995. There is little available information on the potential for disturbance from seismic surveys for harbour seal, however, observations of behavioural changes in other seal species have shown avoidance reactions up to 3.6km from the source for a seismic survey (Harris et al., 2001). A more recent assessment of

potential for disturbance to seal species, as a result of seismic surveys, shows potential disturbance ranges from 13.3km to 17.0km from source (BEIS, 2020).

996. A potential disturbance range of 17.0km (or disturbance area of 907.9km^2 for one survey, and 1,815.8km^2 for up to two seismic surveys) will therefore be applied to harbour seal due to a lack of species-specific information.

997. As the location of the potential geophysical surveys is currently unknown, the following assessment for harbour seal uses the average density estimate across the Carter *et al.* (2022) relative density dataset for The Wash and North Norfolk Coast SAC of 0.027/km^2. This therefore assumes that there could be up to two geophysical surveys within the area at which harbour seal associated with The Wash and North Norfolk Coast SAC may be present.

Table 6.77 Quantitative assessment for cumulative disturbance of harbour seal due to up to two oil and gas seismic surveys

Project	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.00005	1,963.5	0.10
Up to two seismic surveys	0.27	1,815.8	49.0
Total number of seals (without NF)			49.1 49.0
Percentage of SAC population (without NF)			1.24% 1.24%

998. Only one subsea pipeline has been screened into the cumulative assessment; Sea Link. This project is currently at scoping stage and therefore there is limited information available on potential effects and disturbance ranges for which to inform a cumulative assessment with North Falls.

999. The disturbance ranges that could be generated during the cabling works and vessels would be up to 4km (with a disturbance area of 50.3km^2), for harbour seal. This has been used to inform the assessments for subsea cabling and pipeline projects, as activities would be similar, in the absence of any additional information for the project screened in for assessment.

1000. The density for the Sea Link project has been estimated based on the Carter *et al.* (2022) relative density data for The Wash and North Norfolk Coast SAC, with an estimated density (for only those harbour seals that are associated with the SAC) of 0.001/km^2.

Table 6.78 Quantitative assessment for cumulative disturbance of harbour seal due to cable and pipeline projects

Project	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.00005	1,963.5	0.10
Cable and pipeline projects	0.001	50.3	0.05

Project	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
Total number of seals (without NF)			0.15 0.05
Percentage of SAC population (without NF)			0.004% 0.001%

1001. It is currently not possible to estimate the number of potential UXO clearance events that could be undertaken at the same time as construction and potential piling activity at North Falls, and therefore, on a worst case basis, the potential for one high-order clearance and one low-order clearance has been assessed as having the potential to take place at the same time.

1002. The potential effect area during a single UXO clearance event, based on the modelled worst case effect range at North Falls for TTS / fleeing response (weighted SEL) of 22.0km (1,520.5km^2) for high-order clearance and 0.8km (2.01km^2) for low-order clearance.

1003. However, as outlined in the BEIS (2020) RoC HRA, due to the nature of the sound arising from the detonation of UXO, i.e. each blast lasting for a very short duration, marine mammals, are not predicted to be significantly displaced from an area, any changes in behaviour, if they occur, would be an instantaneous response and short-term. Guidance suggests that disturbance behaviour is not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC, 2010).

1004. Mitigation measures required for UXO clearance include the use of low-order clearance techniques, which could include a small donor charge, rather than full high-order detonation which is only used as a last resort. It is therefore highly unlikely that more than one UXO high-order detonation would occur at exactly the same time or on the same day as another UXO high-order detonation, even if they had overlapping UXO clearance operation durations. The in-combination assessment is therefore based on potential for disturbance from one UXO high-order detonation without mitigation (worst case), as well as one low-order clearance event.

1005. As the location of the potential UXO clearances are currently unknown, the following assessment for harbour seal uses the average density estimate across The Wash and North Norfolk Coast SAC of 0.027/km^2.

Table 6.79 Quantitative assessment for cumulative disturbance of harbour seal due to UXO clearance

Potential cumulative effect	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
North Falls	0.00005	1,963.5	0.10
One high-order UXO detonation	0.027	1,520.5	41.1

Potential cumulative effect	Harbour seal density (based on The Wash and North Norfolk Coast SAC relative densities) (/km^2)	Potential cumulative effect area (km^2)	Maximum number of individuals potentially disturbed
One low-order UXO detonation	0.027	2.01	0.05
Total number of seals (without NF)			41.2 41.1
Percentage of SAC population (without NF)			1.04% 1.04%

Summary of cumulative effect 1: assessment of disturbance from all noisy activities associated with offshore industries

1006. Each of the above described other noise sources are quantitively assessed together in Table 6.80.

1007. For noisy activities (other than OWF) with the potential for cumulative disturbance effects together with piling at North Falls, for harbour seal, up to 16.8% of the SAC population is at risk of disturbance, if all included activities were undertaken at the same time.

1008. It should be noted that while the projects included within the cumulative assessment for disturbance from other activities and industries were done so based on the current knowledge of their possible construction or activity windows, and it is very unlikely that all activities would be taking place on the same day or in the same season, and therefore this likely represents an over-precautionary and worst case estimate of the marine mammals that could be at risk of disturbance during the three year offshore construction period of North Falls.

1009. As shown in Table 6.80 below, North Falls accounts for a very small proportion of harbour seal that may be disturbed due to OWF piling (a total of 0.1 individuals out of the 663.9 that may be disturbed in total, or 0.015% of the total seals at risk of disturbance). For the DCO application, the assessment will be updated to take account of further information on project dates, any detail on project level mitigation commitments or marine licence conditions from the in-combination projects and the assessment will be amended accordingly. In the case that a significant proportion of The Wash and North Norfolk SAC harbour seal population are at risk of disturbance at that stage, population modelling would be undertaken (using PCoD) to determine whether there is the potential for a population level effect, and therefore whether there is the potential for the FCS of harbour seal to be affected.

1010. As shown in the above assessments, the majority of harbour seal at risk of disturbance are from OWF piling, with those projects that are within close proximity of The Wash and North Norfolk Coast SAC contributing a large proportion of the in-combination disturbance. Therefore, there is limited opportunity for North Falls to significantly reduce the overall potential disturbance effect to The Wash and North Norfolk Coast SAC population.

Table 6.80 Quantitative assessment for all noisy activities with the potential for cumulative disturbance effects for harbour seal

Noisy activity	Maximum number of harbour seal potentially disturbed
North Falls	0.1
Piling at other OWFs	569.1
Construction activities at other OWFs	0.2
Up to two geophysical surveys	4.2
Aggregates and dredging	0.2
Up to two oil and gas seismic surveys	49.0
Subsea cables and pipelines	0.1
UXO clearance	41.1
Total number of individuals (without North Falls)	663.9 663.8
Percentage of Humber Estuary SAC (without North Falls)	16.83% 16.82%

6.4.3.4.2 In-combination impact 2: Barrier effects

1011. It is important to note that the OWFs and other noise sources included in the in-combination assessment are spread over the wider area of the North Sea. Taking into account the locations of the OWFs and other noise sources from North Falls, the maximum underwater effect ranges for disturbance at other projects would not overlap with the maximum underwater effect ranges for disturbance at North Falls during piling and construction. Therefore, there is no potential for underwater noise from North Falls, other OWFs and noise sources to result in a barrier of movement to harbour seal.

1012. There would be no adverse effect due to barrier effects on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.4.3 In-combination impact 3: Increased collision risk with vessels

1013. The increased collision risk even using a very precautionary approach, has an effect significance of minor adverse (with mitigation), with a low number of marine mammals at risk.

1014. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore there would be no increased collision risk as the increase in the number OWF vessels would be relatively small compared to the baseline levels of vessel movements in these areas.

1015. Once on-site, OWF vessels would be stationary or slow moving, as they undertake the activity they are associated with. Therefore, the risk of any increased collision risk for marine mammals would be negligible, if any.

1016. Vessels associated with aggregate extraction and dredging are large and typically slow moving, using established transit routes to and from ports. Therefore, the potential increased collision risk with vessels is considered to be extremely low or negligible. Therefore, increased collision risk from aggregate extraction and dredging has been screened out from further consideration in the in-combination assessment.

1017. Good practice measures, as implemented for North Falls, would ensure any risk of vessels colliding with marine mammals is avoided.

1018. There would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.4.3.4.4 In-combination impact 4: Changes in prey resource

1019. For any potential changes to prey resources, it has been assumed that any potential effects on harbour seal prey species from underwater noise, including piling, would be the same or less than those for harbour seal. Therefore, there would be no additional in-combination effects other than those assessed for harbour seal (i.e. if prey are disturbed from an area as a result of underwater noise, harbour seal will be disturbed from the same or greater area). As a result any changes to prey resources would not affect harbour seal as they would already be disturbed from the area.

1020. Any effects to prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat for prey species in the surrounding area.

1021. Taking into account the assessment for North Falls alone (Sections 6.4.3.1.7), and assuming similar effects for other projects and activities, along with the range of prey species taken by harbour seal and the extent of their foraging ranges, there would be no potential for in-combination effect on harbour seal populations as a result of changes to prey resources.

1022. Therefore, there would be no adverse effect on the integrity of The Wash and North Norfolk Coast SAC in relation to the conservation objectives for harbour seal.

6.5 Other European sites

6.5.1 Conservation objectives

1023. All the screened in European Designated Sites use the OSPAR Conservation Objectives:

- to protect, conserve and restore species, habitats and ecological processes which have been adversely affected by human activities;
- to prevent degradation of, and damage to, species, habitats and ecological processes, following the precautionary principle;
- to protect and conserve areas that best represent the range of species, habitats and ecological processes in the maritime area.

6.5.2 Vlaamse Banken SAC

6.5.2.1 Site overview

1024. The Vlaamse Banken SAC has been recognised as an SAC since October 2012. The SAC is a designated site for the marine mammals harbour porpoise, harbour seal and grey seal (EUNIS, 2022).

1025. The Vlaamse Banken SAC covers an area of 1,099 km^2. The SACs closest point to the North Falls array areas is 34km.

6.5.2.2 Qualifying feature

6.5.2.2.1 Harbour porpoise

1026. There is no site-specific data on harbour porpoise estimates available. Hence, a wider search approach was applied. More reliable data on abundance data could be derived from data collected in all Belgian waters.

1027. Average densities in the Belgium waters range from 0.2 -4 animals/km^2; a total was estimated at 10,000 harbour porpoises or 3% of the best North Sea population estimate (Haelters, 2016).

1028. There are seasonal differences in distribution: aerial and acoustic surveys indicated that harbour porpoise is abundant in late winter and early spring, with lower numbers in more offshore and northerly waters during late spring and summer. In autumn, harbour porpoise densities in offshore areas (Haelters et al., 2010).

6.5.2.2.2 Harbour seal

1029. A study in 2010 revealed that along the Belgian coast, no harbour seal colonies or stable haul out sites exist anymore (Hassani et al. 2010).

1030. The Belgian sightings & strandings database however logged 598 harbour seal sightings since 2002 (Belgian Marine Data Centre, 2023) along the Belgium coast.

1031. Harbour seal abundance and distribution has been assessed for the Greater North Sea and Celtic Sea. Belgium however is not listed as having seal monitoring programmes (OSPAR, 2017). Belgium is however joined with Netherlands in the Belgium Coast and Dutch Delta Assessment Unit, and together account for <1% of the relative proportion of harbour seals in each assessment unit.

6.5.2.2.3 Grey seal

1032. Along the southern Dutch and Belgian coasts small groups are regularly observed, but no colonies have yet been established (Härkönen et al. 2007)

6.5.2.3 Shadow appropriate assessment

1033. To assess the site most appropriately, despite the lack of site-specific species population data, a precautionary approach for the assessment has been used.

1034. The SNS SAC (Section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries. Given the distance between the Project and Vlaamse Banken SAC the potential effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1035. Tracking data of harbour seals (Carter et al., 2020 (

1036.

1037. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Vlaamse Banken SAC could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1038. Grey seal tracking data (Carter et al., 2020 (

1039.

1040. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belguim, although there is movement of seals to south-east England. This suggests that grey seals in Vlaamse Banken SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC.

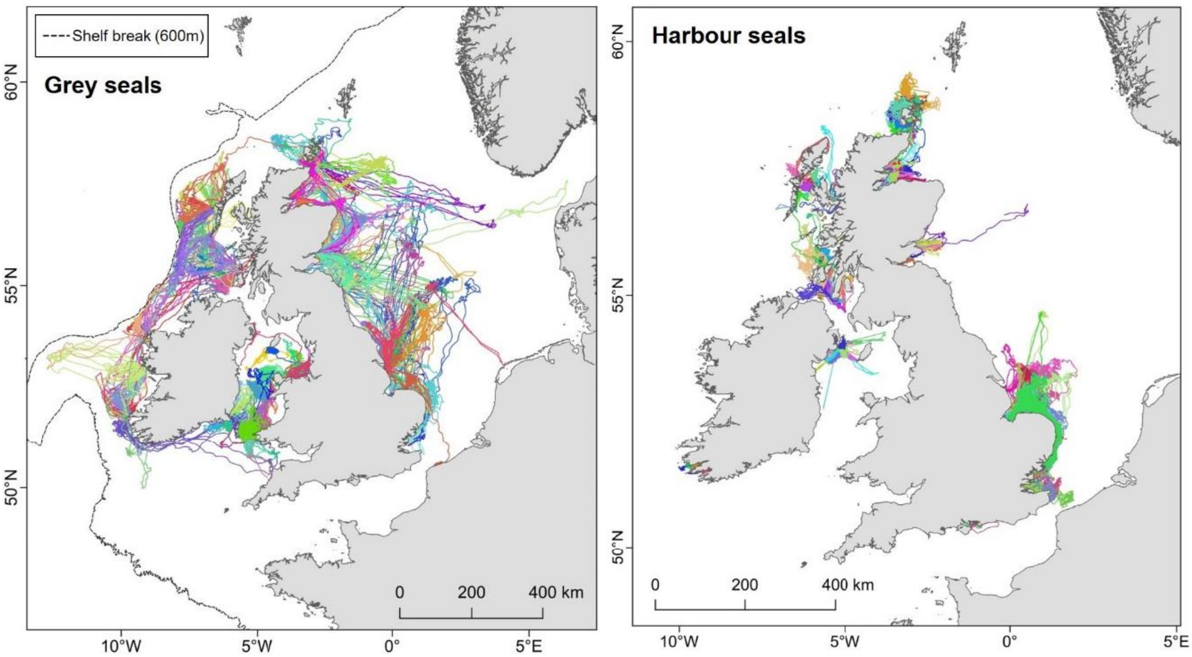

Plate 6.1 Tracking data for grey and harbour seals (coloured by individual (grey seals = 114; harbour seals = 239)) (Carter *et al.*, 2020)

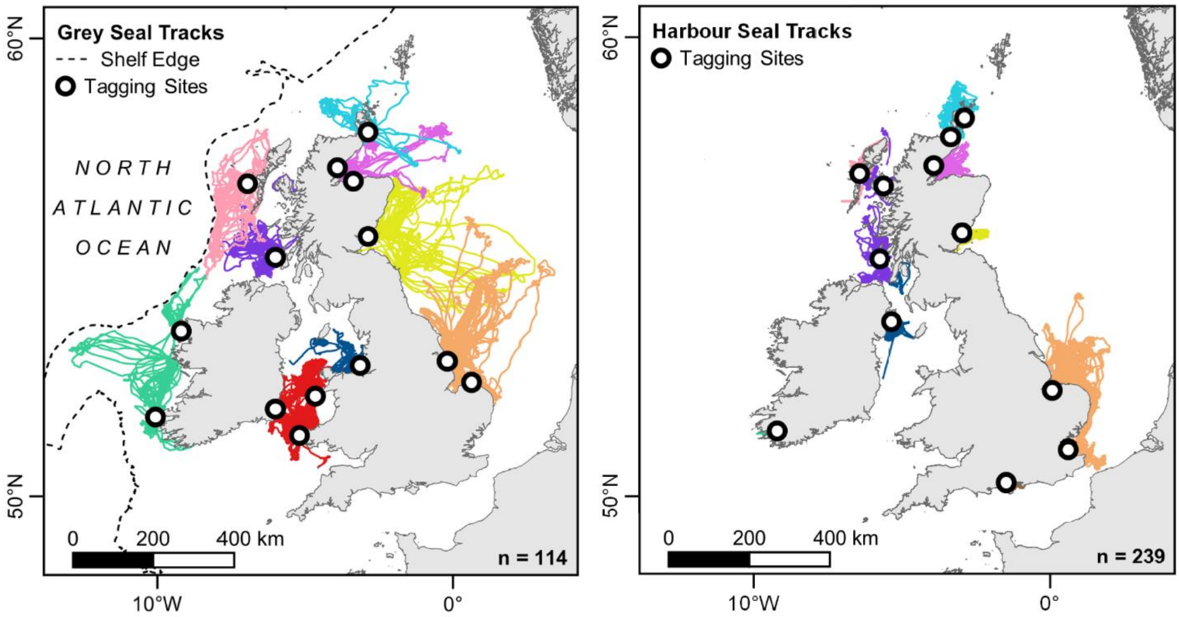

Plate 6.2 Tracking data for grey seal and harbour seals, colour-coded by habitat preference region (data shown have been cleaned to remove erroneous location estimates, trips between regions and locations during the corresponding species' breeding season) (Carter *et al*., 2022)

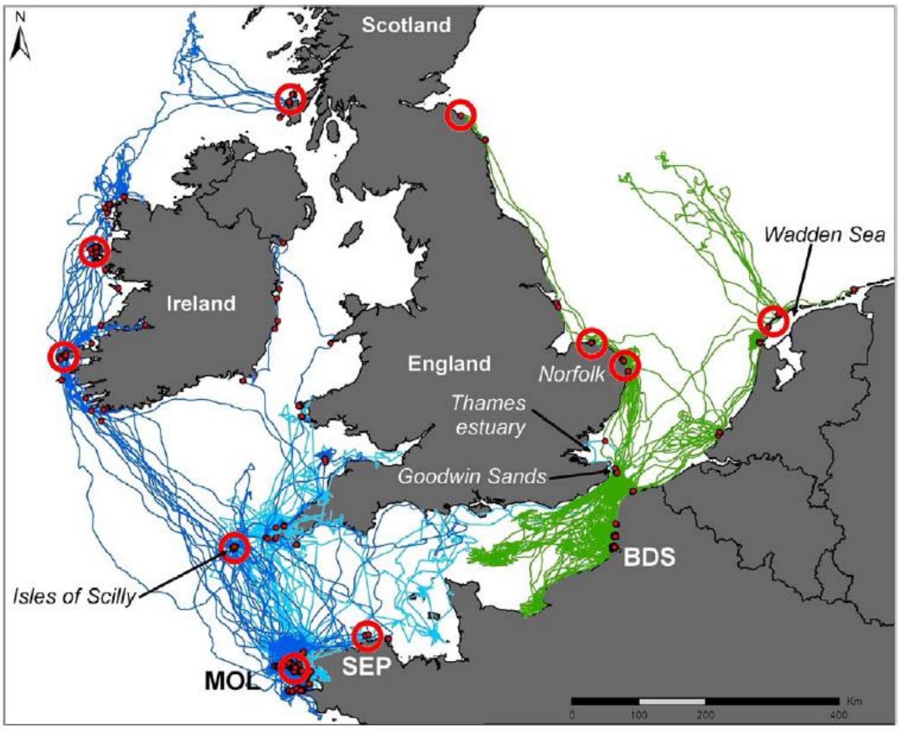

Plate 6.3 Grey seal telemetry tracks from Molene archipelago (MOL) (15 individuals from 1999 to 2003, in light blue, and 19 individuals from 2010 to 2013, in dark blue) and Baie de Somme (BDS) (11 individuals tracked in 2012, in green) (Vincent *et al*., 2017)

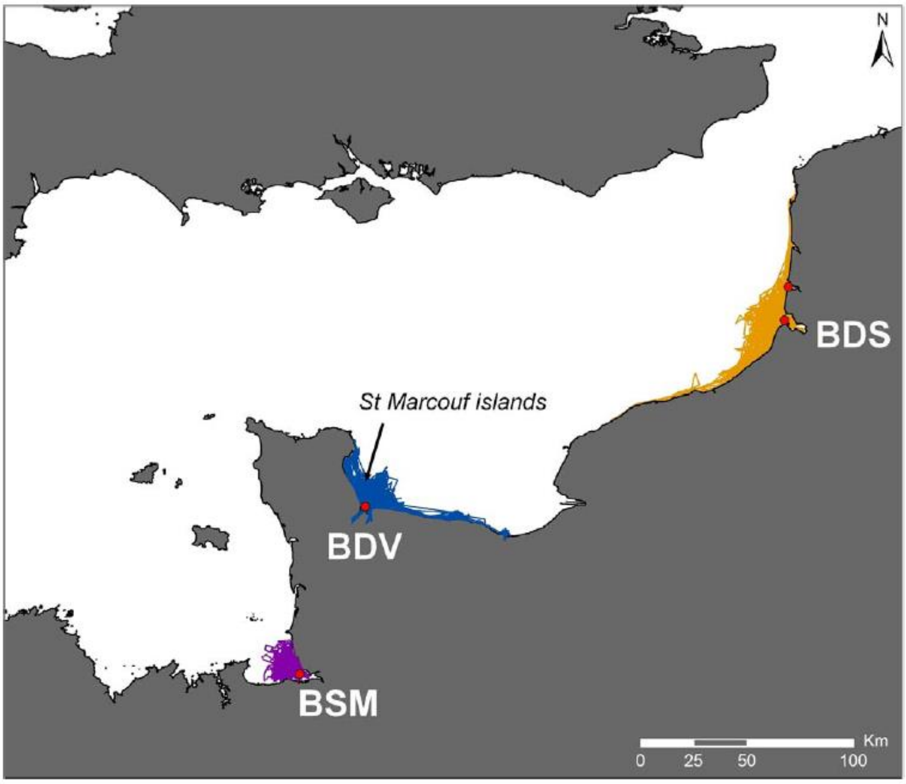

Plate 6.4 Harbour seal telemetry tracks from Baie du Mont Saint-Michel (BSM) (6 individuals tracked in 2006 and 2007, in purple), Baie des Veys (BDV) (12 individuals tracked in 2007 and 2008, in blue) and Baie de Somme (BDS) (10 individuals tracked in 2010, in orange) (Vincent *et al*., 2017)

1041. Table 6.81 summarise the assessment of potential effects on Vlaamse Banken SAC on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1042. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal. Under these circumstances, there is no adverse effect on the integrity of the Vlaamse Banken SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.81 Summary of potential construction effects for qualifying features of the Vlaamse Banken SAC (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.3 SBZ 1 / ZPS 1 SPA

6.5.3.1 Site overview

1043. The SBZ 1 / ZPS 1 SPA been recognised as an SPA since October 2005. The SAC is a designated site for harbour seals (EUNIS, 2022).

1044. The SBZ 1 / ZPS 1 SPA covers an area of 63 km^2. The SPAs closest point to the North Falls array areas is 63km.

6.5.3.2 Qualifying feature

1045. This SAC lies within the Vlaamse Banken SAC (as assessed in Section 6.5.2); it is therefore likely that the information on harbour seal will overlap.

6.5.3.2.1 Harbour seal

1046. There is no site-specific data on harbour seal estimates available. Harbour seals are frequenting here for predation reasons (Natura 2000) but may also be due to the proximity to the resting site at Phare du Walde. This site lies approximately 50 km west of the SAC, where a maximum number of 16 harbour seals hauled out during molt (late July- early September) in 2019 (Poncet et al. 2021). The southernmost harbour seal colonies in the NE Atlantic lie in northern France; with an increasing number since mid-1990 (Andersen & Olsen, 2010; Poncet et al. 2021)

6.5.3.3 Shadow appropriate assessment

1047. In order to assess the potential effects of North Falls on SBZ 1 / ZPS 1 SPA, refer to the assessment of Vlaamse Banken SAC (Section 6.5.1). The effects on SBZ 1 / ZPS 1 SPA will likely to be similar, as it is nested within the Vlaamse Banken SAC (see Table 6.81).

1048. Therefore, there is no adverse effect on the integrity of the SBZ 1 / ZPS 1 SPA in relation to the conservation objectives for harbour seal.

6.5.4 Vlakte van de Raan SCI

6.5.4.1 Site overview

1049. The Vlakte van de Raan SCI been recognised as an SCI since December 2009. The SAC is a designated site for harbour porpoise, grey seals and harbour seals (EUNIS, 2022).

1050. The Vlakte van de Raan SCI covers an area of 175km^2. The SCIs closest point to the North Falls array areas is 85km.

6.5.4.2 Qualifying features

6.5.4.2.1 Harbour porpoise

1051. In a report by Flanders Research Institute for Agriculture, Fisheries and Food, it stated that the area of the Vlakte van den Raan SCI has the lowest densities of harbour porpoise found in Belgian waters (Degraer & Hostens, 2016).

1052. Average densities in 2008 and 2009, as estimated by aerial monitoring covering most of the Belgian part of the North Sea (with the exclusion of a nearshore 5 km strip) 0.05 in August to 1.01 animals/km^2 in April (Haelters et al., 2011).

1053. The extent is unclear to which the SCI is of special significance to the normal reproduction, mortality and age structure of harbour porpoise and so it concluded that the ecological value for harbour porpoise is negligible and hence the conservation status to change to 'unfavourable-inadequate' (Jak et al. 2009).

1054. The specific conservation target is to maintain the habitat and population of the species may be adopted for this SCI to a restoration task (Jak et al. 2009).

6.5.4.2.2 Grey seal

1055. Along the southern Dutch and Belgian coasts small groups are regularly observed, but no colonies have yet been established (Härkönen et al. 2007).

1056. At site level there is no data on grey seals; it is proposed that grey seals may forage here but have their refuge elsewhere (Jak et al. 2009).

6.5.4.2.3 Harbour seal

1057. Telemetry data shows evidence that presence pf harbour seal is limited due to the lack of tidal flats and is therefore not used as reproduction or haul out area (Jak et al. 2009).

6.5.4.3 Shadow appropriate assessment

1058. To assess the site most appropriately, despite the lack of site-specific species population data, a precautionary approach for the assessment has been used. The SNS SAC (Section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries.

1059. Given the slightly longer distance between North Falls and Vlakte van de Raan SCI, the effects on harbour porpoise would likely to be similar or less than those assessed in the SNS SAC.

1060. Tracking data of harbour seals (Carter et al., 2020 (

1061.

1062. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Vlakte van de Raan SCI could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1063. Grey seal tracking data (Carter et al., 2020 (

1064.

1065. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belguim, although there is movement of seals to south-east England. This suggests that grey seals in Vlakte van de Raan SCI are less likely to be connected to the North Falls area than the Humber Estuary SAC.

1066. Table 6.82 summarises the assessment of potential effects on Vlakte van de Raan SCI on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1067. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no adverse effect on the integrity of the Vlakte van de Raan SCI in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.82 Summary of potential construction effects for qualifying features of the Vlakte van de Raan (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.5 Bancs des Flandres SAC

6.5.5.1 Site overview

1068. The Bancs des Flandres SAC been recognised as an SAC since February 2016. The SAC is a designated site for harbour porpoise, grey seals and harbour seals (EUNIS, 2022).

1069. The Bancs des Flandres SAC covers an area of 1,129 km^2. The SACs closest point to the North Falls array areas is 37km.

6.5.5.2 Qualifying features

6.5.5.2.1 Harbour porpoise

1070. Data shows that this area is one of the two French sites commonly frequented by the harbour porpoise to forage (Natura 2000).

1071. However, there is no site-specific data on harbour porpoise estimates available. Hence, a wider search approach was applied. More reliable data on abundance data could be derived from data collected in the English Channel.

1072. According to SCANS III, the estimates for harbour porpoise abundance was zero in the English Channel (Hammonds et al. 2017). Distribution maps by the Sea Watch Foundation showed no sightings in the western part of the English Channel apart from December, near the English coast by the Isle of Wight. Observed density distributions between1994 and 2011 are mainly below 0.3 in 25km grid cells (Heinaenen & Skov, 2015).

6.5.5.2.2 Grey seal

1073. Plate 6.5 indicates an important haul out sites for grey seals, with maximum numbers of seals in the summer of 282 and 117 during moulting (February-March) (Poncet et al. 2021).

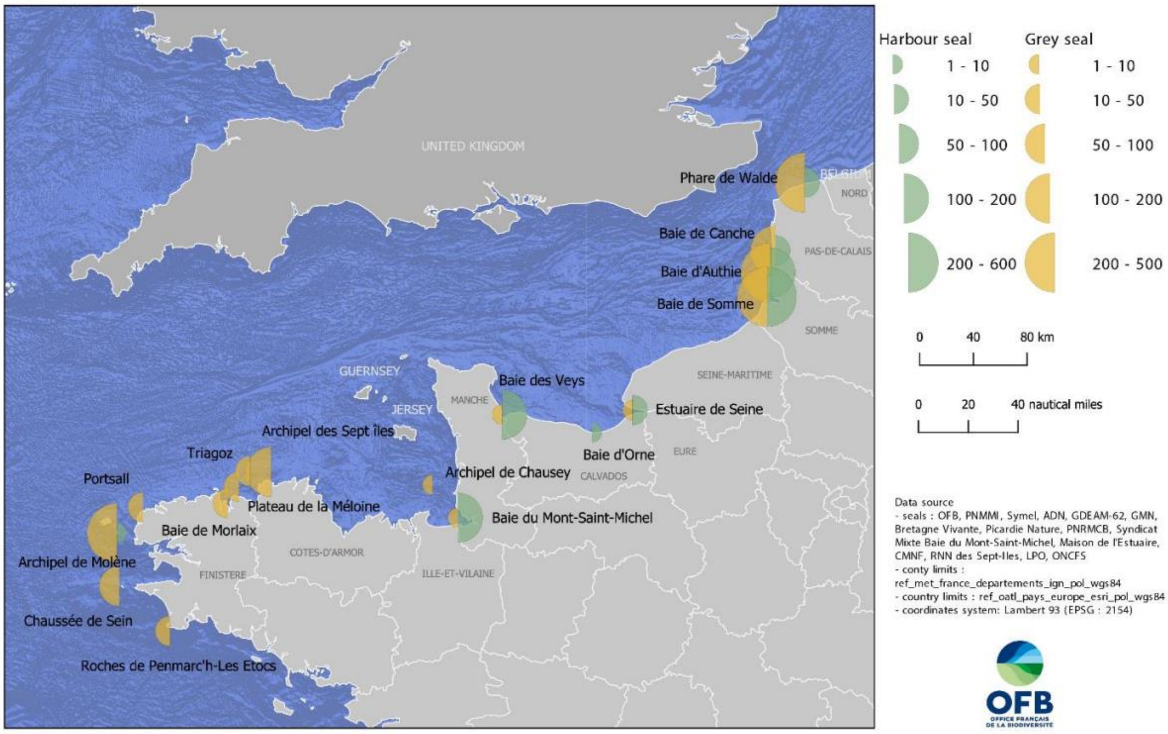

Plate 6.5 Grey seal haul out sites (source: Poncet *et al.,* 2019)

6.5.5.2.3 Harbour seal

1074. There is no site-specific data on harbour seal estimates available. Harbour seals are frequenting here for predation reasons (Natura 2000) but may also be due to the proximity to the resting site at Phare du Walde. This site lies approximately 6 km south of the nearest point to the SAC, where a maximum number of 16 harbour seals hauled out during molt (late July- early September) in 2019 (Poncet et al. 2021).

1075. The southernmost harbour seal colonies in the NE Atlantic lie in northern France; with an increasing number since mid-1990 (Andersen & Olsen, 2010; Poncet et al. 2021)

6.5.5.3 Shadow appropriate assessment

1076. To assess the site most appropriately, despite the lack of site-specific species population data, a precautionary approach for the assessment has been used. The SNS SAC (Section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries. Given the distance between the Project and Bancs de Flandres SAC the effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1077. Tracking data of harbour seals Carter et al., 2020 (

1078.

1079. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Bancs de Flandres SAC could potentially utilise this corridor as well, possibly becoming impacted by activities at North Falls, such as vessel collision and underwater noise.

1080. Grey seal tracking data Carter et al., 2020 (

1081.

1082. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with only few examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. This suggests that grey seals in Bancs de Flandres SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC.

1083. Table 6.83 summarises the assessment of potential effects on Bancs de Flandres SAC on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1084. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no adverse effect on the integrity of the Bancs de Flandre SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.83 Summary of potential construction effects for qualifying features of the Bancs de Flandre SAC (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.6 Dunes De La Plaine Maritime Flamande SAC

6.5.6.1 Site overview

1085. The Dunes De La Plaine Maritime Flamande SAC been recognised as an SAC since April 2007. The SAC is a designated site for harbour seals (EUNIS, 2022).

1086. The Dunes De La Plaine Maritime Flamande SAC covers an area of 44 km^2. The SACs closest point to the North Falls array areas is 69km.

6.5.6.2 Qualifying feature

6.5.6.2.1 Harbour seal

1087. There is no site-specific data on harbour seal estimates available. There are several harbour seals Phare du Walde, a site which falls into the SAC. Here, maximum numbers of harbour seals hauled out during molt (late July- early September) were 16 in 2019 (Poncet et al. 2021). The proximity to this haul out site might give indication as to why harbour seals are frequenting in the SAC (resting and predation) (Natura 2000).

1088. The southernmost harbour seal colonies in the NE Atlantic lie in northern France; with an increasing number since mid-1990 (Andersen & Olsen, 2010; Poncet et al. 2021)

6.5.6.3 Shadow appropriate assessment

1089. In order to assess the potential effects of North Falls on harbour seal within the Dunes De La Plaine Maritime Flamande SAC, refer to the assessment of Bancs de Flandre (Section 6.5.5) or Vlaamse Banken SAC (Section 6.5.2). The effects in Dunes De La Plaine Maritime Flamande SAC will likely to be similar, as it is nested within Bancs de Flandre SAC and Vlaamse Banken SAC (see Table 6.81 and Table 6.83), therefore an adverse effect on integrity can be ruled out.

6.5.7 Recifs Gris-Nez Blanc-Nez SAC

6.5.7.1 Site overview

1090. The Recifs Gris-Nez Blanc-Nez SAC been recognised as an SAC since May 2015. The SAC is a designated site for harbour porpoise, grey seals and harbour seals (EUNIS, 2022) since October 2008.

1091. The Recifs Gris-Nez Blanc-Nez SAC covers an area of 292 km^2. The SACs closest point to the North Falls array areas is 73km.

6.5.7.2 Qualifying features

6.5.7.2.1 Harbour porpoise

1092. Comments in the site assessment state that this is a relatively important site for the harbour porpoise, which is regularly visited (Natura 2000).

1093. However, there is no site-specific data on harbour porpoise estimates available. Hence, a wider search approach was applied. More reliable data on abundance data could be derived from data collected in the English Channel.

1094. According to SCANS III, the estimates for harbour porpoise abundance was zero in survey block C (English Channel) (Hammonds et al. 2017. Distribution maps by the SeaWatch Foundation showed no sightings in the western part of the English Channel apart from near the English coast by the Isle of Wight (December). Observed density distributions between 1994 and 2011 are mainly below 0.3 in 25km grid cells (Heinaenen & Skov, 2015).

6.5.7.2.2 Grey seal

1095. There is no site-specific data on grey seal estimates available. Grey seals are frequenting here for predation reasons (Natura 2000) but may also be due to the proximity to two haul-out sited north-east and south of the SAC, Phare du Walde and Baie de Canche, respectively. At Phare du Walde, approximately 16km west of the SAC, maximum of 282 grey seals haul out in the summer and 117 during moulting (February- March). At Baie de Canche, approximately 25 km south of the SAC, a maximum of 108 grey seals were counted in 2019 during moult (February-March) (Poncet et al. 2021).

6.5.7.2.3 Harbour seal

1096. There is no site-specific data on harbour seal estimates available, but at Phare du Walde, north-east of the SAC, maximum numbers of 16 harbour seals were hauled out during molt (late July- early September) 2019 (Poncet et al. 2021). This would explain their presence in the site and may use the SAC as their feeding grounds (Natura 2000).

1097. South of the SAC is another haul out site, Baie de Canche, where 49 harbour seals and 4 pups were counted in 2019 during moult (February-March) (Poncet et al. 2021).

1098. There is no site-specific data on harbour seal estimates available. Harbour seals are frequenting here for predation reasons (Natura 2000) but may also be due to the proximity to two haul-out sited north-east and south of the SAC, Phare du Walde and Baie de Canche, respectively. At Phare du Walde, maximum numbers of harbour seals hauled out during molt (late July- early September) were 16 in 2019, and at Baie de Canche 49 harbour seals and 4 pups were counted in 2019 during moult (February-March) (Poncet et al. 2021).

6.5.7.3 Shadow appropriate assessment

1099. To assess the site most appropriately, despite the lack of site-specific species population data, a precautionary approach for the assessment has been used. The SNS SAC (Section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries. Given the distance between the Project and Recifs Gris-Nez Blanc-Nez SAC the effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1100. Tracking data of harbour seals (Carter et al., 2020 (

1101.

1102. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast

SAC. This suggests that harbour seals from the Recifs Gris-Nez Blanc-Nez SAC could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1103. Grey seal tracking data (Carter et al., 2020 (

1104.

1105. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belguim, although there is movement of seals to south-east England. This suggests that grey seals in Recifs Gris-Nez Blanc-Nez SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC.

1106. Table 6.84 summarises the assessment of potential effects Recifs Gris-Nez Blanc-Nez SAC on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1107. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no adverse effect on the integrity of the Recifs Gris-Nez Blanc-Nez SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.84 Summary of potential construction effects for qualifying features of the Recifs Gris-Nez Blanc-Nez SAC (x = no potential for adverse effect on site integrity; √= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.8 Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC

6.5.8.1 Site overview

1108. The Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC been recognised as an SAC since August 2015. The SAC is a designated site for harbour seals (EUNIS, 2022).

1109. The Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC covers an area of 11 km^2. The SACs closest point to the North Falls array areas is 82km.

6.5.8.2 Qualifying features

1110. This SAC lies within the Recif Gris-Nez Blanc-Nez SAC; it is therefore highly likely that the information on qualifying features will overlap.

6.5.8.2.1 Harbour porpoise

1111. Comments in the site assessment state that this is a relatively important site for the harbour porpoise, which is regularly visited (Natura 2000).

1112. However, there is no site-specific data on harbour porpoise estimates available. Hence, a wider search approach was applied. More reliable data on abundance data could be derived from data collected in the English Channel.

1113. According to SCANS III, the estimates for harbour porpoise abundance was zero in survey block C (English Channel) (Hammonds et al. 2017. Distribution maps by the SeaWatch Foundation showed no sightings in the western part of the English Channel apart from near the English coast by the Isle of Wight (December). Observed density distributions between 1994 and 2011 are mainly below 0.3 in 25km grid cells (Heinaenen& Skov, 2015).

6.5.8.2.2 Harbour seal

1114. There is no site-specific data on harbour seal estimates available. Harbour seals are frequenting here for predation reasons (Natura 2000) but may also be due to the proximity to two haul-out sited north-east and south of the SAC, Phare du Walde and Baie de Canche, respectively. At Phare du Walde, maximum numbers of harbour seals hauled out during molt (late July- early September) were 16 in 2019, and at Baie de Canche 49 harbour seals and 4 pups were counted in 2019 during moult (February-March) (Poncet et al. 2021).

6.5.8.2.3 Grey seal

1115. There is no site-specific data on grey seal estimates available. Grey seals are frequenting here for predation reasons (Natura 2000) but may also be due to the proximity to two haul-out sited north-east and south of the SAC, Phare du Walde and Baie de Canche, respectively. At Phare du Walde, approximately 16km west of the SAC, maximum of 282 grey seals haul out in the summer and 117 during moulting (February- March). At Baie de Canche approximately 108 grey seals were counted in 2019 during moult (February-March) (Poncet et al. 2021).

6.5.8.3 Shadow appropriate assessment

1116. In order to assess the potential effects of North Falls on Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC, refer to the assessment of Recifs Gris-Nez Blanc-Nez SAC (Section 6.5.7). The potential effects will likely to be similar, as Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC it is nested within Recifs Gris-Nez Blanc-Nez SAC (see Table 6.84).

1117. Therefore, there is no adverse effect on the integrity of Falaises du Cran aux Oeufs et du Cap Gris-Nez, Dunes du Chatelet, Marais de Tardinghen et Dunes de Wissant SAC in relation to the conservation objectives for harbour porpoise, grey seal, or harbour seal.

6.5.9 Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC

6.5.9.1 Site overview

1118. The Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC been recognised as an SAC since February 2016. The SAC is a designated site for harbour porpoise, grey seals, and harbour seals (EUNIS, 2022).

1119. The Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC SAC covers an area of 682 km^2. The SACs closest point to the North Falls array areas is 82km.

6.5.9.2 Qualifying features

1120. This SAC shares some of its northern area within the greater SAC of Recif Gris-Nez Blanc-Nez; it is therefore highly likely that the information on qualifying features will be similar.

6.5.9.2.1 Harbour porpoise

1121. There is no site-specific data on harbour porpoise estimates available. Hence, a wider search approach was applied. More reliable data on abundance data could be derived from data collected in the English Channel.

1122. According to SCANS III, the estimates for harbour porpoise abundance was zero in survey block C (English Channel) (Hammonds et al. 2017). Distribution maps by the SeaWatch Foundation showed no sightings in the western part of the English Channel apart from December, near the English coast by the Isle of Wight. Observed density distributions between1994 and 2011 are mainly below 0.3 in 25km grid cells (Heinaenen& Skov, 2015).

6.5.9.2.2 Harbour seal

1123. There is no site-specific data on harbour seal estimates available. The SAC lies offshore of three important haul-out sites at baie de Somme, baie d'Authie and baie de Canche. Based on the swimming ranges of harbour seals (273 km; Carter et al., 2022), the seals from these sites could potentially use the offshore area for foraging reasons. During moult (late July-early September) a maximum of 777 harbour seals were counted at all three locations and would give the best estimate of regional population numbers. The pup production was the highest at Baie de Somme with 149 pups, the highest of all French haul-out sites (Poncet et al. 2021).

6.5.9.2.3 Grey seal

1124. There is no site-specific data on grey seal estimates available. The SAC lies offshore of three important haul-out sites at baie de Somme, baie d'Authie and baie de Canche. Based on the extensive swimming ranges of grey seals (448 km; Carter et al., 2022), the seals from these sites could potentially use the offshore area for foraging reasons. During summer, the maximum hauled out grey seals at all three locations were 448 and 312 during moult (February-March) in 2019 (Poncet et al. 2021).

6.5.9.3 Shadow appropriate assessment

1125. In order to assess the potential effects of North Falls on harbour porpoise in on Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC, the same approach as for the SNS SAC (Section 6.2.3) has been applied. Because the North Falls project lies within SNS SAC, it is therefore considered the worst-case scenario. Given the longer distance between the project and Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC, the effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1126. Tracking data of harbour seals (Carter et al., 2020 (

1127.

1128. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1129. Grey seal tracking data (Carter et al., 2020 (

1130.

1131. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belguim, although there is movement of seals to south-east England. This suggests that grey seals in Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC.

1132. Table 6.85 summarise the assessment of potential effects on Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1133. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no potential adverse effect on the integrity of the Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

1134. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no potential adverse effect on the integrity of the other European Designated Sites in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.85 Summary of potential construction effects for qualifying features of the Ridens et dunes hydrauliques du detroit du Pas-de-Calais SAC (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.10 Vlakte van de Raan SAC

6.5.10.1 Site overview

1135. The Vlakte van de Raan SAC is a designated site for harbour porpoise, grey seals and harbour seals (EUNIS, 2022) and has been recognised as an SAC since March 2011.

1136. The Vlakte van de Raan SAC covers an area of 190 km^2. The SACs closest point to the North Falls array areas is 82km.

6.5.10.2 Qualifying features

6.5.10.2.1 Harbour porpoise

1137. Harbour porpoise densities for the Dutch Delta region were estimated at 0.71 in summer 2019, totaling to 14,713 individuals (Geelhoed et al., 2020).

6.5.10.2.2 Harbour seal

1138. A range of 101 and 250 individual harbour seals were counted (Natura 2000). Within the greater area of the Dutch Delta, harbour seal counts ranged from 677- 2581 from (2011-2021) (Compendium of the Living Environment 2022.

6.5.10.2.3 Grey seal

1139. A maximum of 400 individual grey seals were counted (Natura 2000). Within the greater area of the Dutch Delta, harbour seal counts ranged from 677- 2581 from (2011-2021) (Compendium of the Living Environment 2022).

6.5.10.3 Shadow appropriate assessment

1140. To assess the site most appropriately, despite the lack of site-specific species population data, a precautionary approach for the assessment has been used. The SNS SAC (Section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries. Given the slightly longer distance between the Project and Vlakte van de Raan SAC the effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1141. Tracking data of harbour seals (Carter et al., 2020 (

1142.

1143. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Vlakte van de Raan SAC could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1144. Grey seal tracking data (Carter et al., 2020 (

1145.

1146. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belgium, although there is movement of seals to south-east England. This suggests that grey seals in Vlakte van de Raan SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC.

1147. Table 6.86 summarises the assessment of potential effects on Vlakte van de Raan SAC on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1148. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no potential adverse effect on the integrity of the Vlakte van de Raan SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.86 Summary of potential effects for qualifying features of Vlakte van de Raan SAC (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.11 Voordelta SAC and SPA

6.5.11.1 Site overview

1149. The Voordelta SAC and SPA the designated site is for harbour porpoise, grey seals and harbour seals (EUNIS, 2022).

1150. The Voordelta SAC and SPA covers an area of 835 km^2. The SACs closest point to the North Falls array areas is 87km.

6.5.11.2 *Qualifying features*

6.5.11.2.1 Harbour porpoise

1151. Harbour porpoise densities for the Dutch Delta region were estimated at 0.71 in summer 2019, totaling to 14,713 individuals (Geelhoed et al., 2020).

6.5.11.2.2 Harbour seal

1152. A range of 100-1000 permanent individuals were counted at this site (Natura 2000).

1153. Within the greater area of the Dutch Delta, harbour seal counts ranged from 677- 2581 from (2011-2021) (Compendium of the Living Environment 2022).

6.5.11.2.3 Grey seal

1154. A maximum of 50-200 permanent individuals were counted (Natura 2000).

1155. Within the greater area of the Dutch Delta, harbour seal counts ranged from 677- 2581 from (2011-2021) (Compendium of the Living Environment 2022).

6.5.11.3 *Shadow appropriate assessment*

1156. To assess the site most appropriately, a precautionary approach for the assessment has been used. The SNS SAC (Section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries. Given the distance between the Project and Voordelta SAC the effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1157. Tracking data of harbour seals (Carter et al., 2020 (

1158.

1159. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Voordelta SAC could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1160. Grey seal tracking data (Carter et al., 2020 (

1161.

1162. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belguim, although there is movement of seals to south-east England. This suggests that grey seals in Voordelta SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC.

1163. Table 6.87 summarises the assessment of potential effects Voordelta SAC on the species that were screened in for further assessment as a qualifying feature, based on the assessments undertaken for the SNS SAC for harbour porpoise (Section 6.2.3), Humber Estuary for grey seal (Section 6.3.3), and The Wash and North Norfolk Coast SAC for harbour seal (Section 6.4.3), under the assumption that greater connectivity is expected for the sites within the UK, and therefore the greater potential for effect would be present (and assessed) for the UK sites as noted above.

1164. Disturbance from underwater noise for North Falls alone and in combination with other projects and activities is unlikely to result any significant disturbance or barrier effects for foraging harbour porpoise, harbour seal or grey seal, especially taking into the proposed mitigation approach for harbour porpoise in the SNS SAC. Under these circumstances, there is no potential adverse effect on the integrity of the Voordelta SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.87 Summary of potential construction effects for qualifying features of Voordelta SAC and SPA (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational WTGs	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

6.5.12 Westerschelde and Saeftinghe SAC

6.5.12.1 Site overview

1165. The Westerschelde and Saeftinghe SAC has been recognised as an SAC since February 2010. The SAC is a designated site for harbour porpoise, grey seals and harbour seals (EUNIS, 2022).

1166. The Westerschelde and Saeftinghe SAC covers an area of 441 km^2. The SACs closest point to the North Falls array areas is 99km.

6.5.12.2 Qualifying features

6.5.12.2.1 Harbour porpoise

1167. A range of 1-10 permanent individuals were counted at this site (Natura 2000).

1168. Harbour porpoise densities for the Dutch Delta region were estimated at 0.71 in summer 2019, totalling to 14,713 individuals (Geelhoed et al., 2020).

6.5.12.2.2 Harbour seal

1169. A range of 51-100 permanent individuals were counted at this site (Natura 2000).

1170. Within the greater area of the Dutch Delta, harbour seal counts ranged from 359- 1435 from (2011-2021) (Compendium of the Living Environment 2022).

6.5.12.2.3 Grey seal

1171. A range of 1-20 permanent individuals were counted at this site (Natura 2000)

1172. Within the greater area of the Dutch Delta, harbour seal counts ranged from 677- 2581 from (2011-2021) (Compendium of the Living Environment 2022).

6.5.12.3 Shadow appropriate assessment

1173. To assess the site most appropriately, a precautionary approach for the assessment has been used. The SNS SAC (section 6.2.3) is deemed as the worst-case scenario because the North Falls site lies within the SAC boundaries. Taking into account the distance between the Project, the effects on harbour porpoise would likely to be less than those assessed in the SNS SAC.

1174. Tracking data of harbour seals (Carter et al., 2020 (

1175.

1176. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.4)) show some trips from the southeast of the UK and the Belgian-French coastline, although there is a higher level of connectivity with The Wash and North Norfolk Coast SAC. This suggests that harbour seals from the Westerschelde and Saeftinghe SAC could potentially utilise this corridor as well, possibly becoming affected by activities at North Falls, such as vessel collision and underwater noise.

1177. Grey seal tracking data (Carter et al., 2020 (

1178.

1179. Plate 6.1); 2022 (Plate 6.2), and Vincent *et al.,* 2017 (Plate 6.3)) showed grey seals tagged in Britain are more likely to use the wider offshore North Sea area, with limited examples of tracked grey seals swimming to the north coast of France, Belgium, or Germany. Grey seals tagged in France are more likely to travel along the north coast of France and Belguim, although there is movement of seals to south-east England. This suggests that grey seals in Westerschelde and Saeftinghe SAC are less likely to be connected to the North Falls area than the Humber Estuary SAC. Table 6.88 summarises the assessment of potential effects on Westerschelde and Saeftinghe SAC on the species that were screened in for further assessment as a qualifying feature.

1180. Under these circumstances, there is no potential adverse effect on the integrity of the Westerschelde and Saeftinghe SAC in relation to the conservation objectives for harbour porpoise, grey seal and harbour seal.

Table 6.88 Summary of potential construction effects for qualifying features of Westerschelde and Saefthinghe SAC (x = no potential for adverse effect on site integrity; ✓= potential for adverse effect on site integrity)

Qualifying features	Underwater noise from piling	Underwater noise from other noisy activities	Underwater noise from vessels	Underwater noise from operational	Barrier effect from underwater noise	Collision risk	Prey availability / habitat quality	Water quality	In-combination
Construction phase									
Harbour porpoise	x	x	x	N/A	x	x	x	x	x
Grey Seal	x	x	x	N/A	x	x	x	x	x
Harbour seal	x	x	x	N/A	x	x	x	x	x
Operational phase									
Harbour porpoise	N/A	x	x	x	x	x	x	x	N/A
Grey Seal	N/A	x	x	x	x	x	x	x	N/A
Harbour seal	N/A	x	x	x	x	x	x	x	N/A
Decommissioning phase									
Harbour porpoise	N/A	x	x	N/A	x	x	x	x	N/A
Grey Seal	N/A	x	x	N/A	x	x	x	x	N/A
Harbour seal	N/A	x	x	N/A	x	x	x	x	N/A

7 Offshore Ornithology (Birds Directive Annex 1 and Migratory Species)

7.1 Approach to Assessment

1181. For each European site screened into the Appropriate Assessment a site description is provided. Depending on the information available, this may include information taken from the citation for the site, its conservation objectives, supplementary advice on the conservation objectives, conservation advice, site condition monitoring or other baseline offshore ornithology information.

1182. For each qualifying feature screened into the Appropriate Assessment, the following information is provided:

- The status and condition of the designated population, including any relevant data on population trends;
- A review of key evidence in support of functional linkage or connectivity between the SPA population and North Falls
- Information on the ecology of the species as relevant to the assessment
- An assessment of the potential effects of North Falls on the qualifying feature including a conclusion in relation to the potential for an AEoI; and

- An assessment of potential effects on the qualifying feature when considering North Falls in-combination with other relevant projects and a conclusion in relation to the potential for an AEoI.

1183. Where predicted impacts (either in project alone or in-combination scenarios) equate to an increase of greater than 1% of baseline mortality of the relevant population, then further consideration is undertaken e.g. through population modelling, to determine the significance of the mortality for the population in question. This is the approach recommended by Natural England (2022a).

1184. For PEIR, Project specific population viability analysis (PVAs) have not been run, but reference is made to the outputs of population models for the relevant SPA populations produced recently – usually from DCO examination documents for other OWFs in the southern North Sea. For the HRA accompanying DCO submission, the intention is to run project-specific PVAs using the Natural England modelling tool (Searle et al. 2022).

1185. For the in-combination assessments, OWFs with quantitative information available for a given SPA qualifying feature at the time of preparation of this document have been included. This includes OWFs in tiers 1 to 4 (operational projects, projects in construction, consented projects and those with an application submitted but not yet determined), and tier 5 if a PEIR is publicly available (see PEIR Chapter 13 Offshore Ornithology Volume I, Section 13.7). The approximate cut-off date for this was summer 2022 although in some cases more recently published information has been added.

7.1.1 Consultation

1186. Consultation to date over the HRA screening process for offshore ornithology has been undertaken in line with the general process described in Section 4.2. A detailed record of offshore ornithology consultation comments and responses is included in the HRA screening report (Appendix 1) and the stakeholder comments and discussions at the Offshore Ornithology ETG have been considered in preparing the appropriate assessments included below.

7.1.2 Worst-case scenario

1187. The worst-case scenarios for construction, operation and decommissioning related to the offshore project area and potential impacts on onshore ornithological designated sites are presented in Section 3. The shadow appropriate assessments for each designated site have been based on these worst-case scenarios.

Table 7.1 Realistic worst case scenarios

Potential Impact	Parameter	Notes
Displacement / barrier effect from offshore infrastructure	Array areas (northern and southern array areas) of 150km^2 plus 4km buffer with maximum of 72 WTGs at a minimum spacing of 820m.	
Collision risk	Three design scenarios: • Scenario 1a - 72 WTGs, 164m rotor diameter, (air gap 26.6m above Highest Astronomical Tide (HAT);	Collision Risk Modelling (CRM) has been carried out for all WTG scenarios based on the WTG specifications (see PEIR

Potential Impact	Parameter	Notes
	• Scenario 1b (worst case) - 72 WTGs, 250m rotor diameter, air gap 26.6m above HAT; and • Scenario 2 - 40 WTGs, 337m rotor diameter, air gap 26.6m above HAT.	Volume III, Appendix 13.2). For each bird species, the WTG scenario which produces the highest collision risk has been used in the assessment.

7.1.3 Embedded mitigation

1188. This section outlines the embedded mitigation relevant to the Offshore Ornithology assessment, which has been incorporated into the design of North Falls (Table 7.2).

Table 7.2 Embedded mitigation measures

Parameter	Mitigation measures embedded into North Falls design
Offshore cable corridor	Offshore cable corridor site selection minimises overlap with the Outer Thames Estuary SPA. Site selection was undertaken in consultation with Natural England (see Chapter 4 Site selection and assessment of alternatives, Volume I)
WTG air gap	A minimum air gap (the distance between the lower rotor tip of a WTG and the sea surface of 27m above MHWS (26.6m above HAT). This is an increase of 5m above the minimum of 22m MHWS required for navigation purposes to reduce collision risk for birds (as most seabirds tend to fly low to the sea surface).
Best-practice shipping protocol to minimise disturbance to red-throated divers	This would comprise the following measures for ships associated with North Falls: • designing vessel transit routes during construction, operation and decommissioning as far as possible to minimise transit within the SPA boundary and a 2km buffer; • (in combination with the above) restricting vessel movements to existing navigation routes (where the densities of divers are typically relatively low); • where it is necessary to go outside of established navigational routes, selecting routes that avoid known aggregations of birds; • maintaining direct transit routes (to minimise transit distances through areas used by divers); • avoidance of over-revving of engines (to minimise noise disturbance); and • briefing of vessel crew on the purpose and implications of these vessel management practices (through, for example, tool-box talks).

7.2 Outer Thames Estuary SPA

7.2.1 SPA overview

1189. The Outer Thames Estuary is a marine SPA located adjacent to the east coast of England between the counties of Norfolk (in the north) and Kent (in the south), and extending into the North Sea. The SPA is divided into three parts, a southern component in the Outer Thames area, a second part extending north along the Suffolk and Norfolk Coast, and a third area further offshore from the Norfolk Coast). The site comprises areas of shallow and deeper water, high tidal current streams and a range of mobile mud, sand, silt and gravely sediments extending into the marine environment, incorporating areas of sand banks often exposed at low tide. Intertidal mud and sand flats are found further towards the coast and within creeks and inlets inland down the Blyth estuary and the Crouch and Roach estuaries. In total, approximately 3,924km^2 of habitat is included within the SPA boundary.

1190. The SPA was initially designated in August 2010 solely for non-breeding red-throated divers, with the boundary based on the distribution of this species as recorded in visual aerial surveys flown in the non-breeding season between 1989 and 2006/07 (Natural England and JNCC 2010, 2015; O'Brien et al. 2012), An extended site was subsequently designated in October 2017, including nearshore areas used for foraging in the breeding season by two additional qualifying species, common tern and little tern (JNCC 2023, Natural England and JNCC 2015).

7.2.2 Conservation Objectives

1191. As discussed in Section 5.3.2, the SPA's conservation objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- The extent and distribution of the habitats of the qualifying features;
- The structure and function of the habitats of the qualifying features;
- The supporting processes on which the habitats of the qualifying features rely;
- The populations of each of the qualifying features; and
- The distribution of qualifying features within the site.

1192. Supplementary information on the conservation objectives for qualifying features of the SPA, including specific targets, is provided on Natural England's designated sites view and referred to below.

7.2.3 Shadow Appropriate Assessment

1193. The following qualifying features have been screened in for appropriate assessment (Section4.4):

- Red-throated diver, non-breeding
- Common tern, breeding

1194. At PEIR, an appropriate assessment is presented for red-throated diver only, as the SPA population of this species has been identified as one where North Falls may contribute to an in combination AEoI, along with other UK OWFS in the North Sea. The RIAA which accompanies the DCO submission will include appropriate assessments for all qualifying features of the Outer Thames Estuary that have been screened in.

7.2.3.1 Red-throated diver

1195. Red-throated diver has been screened in for appropriate assessment in relation to displacement/barrier effects during the non-breeding season during the construction/decommissioning and operational phases of the development.

1196. The appropriate assessment presented here deals with the operational phase only, as this is the impact which is identified as a potential AEoI. East Anglia ONE North, which (together with East Anglia TWO), is the most recent OWF in the outer Thames area to undergo DCO examination, has been consented subject to derogation and compensation measures for displacement of red-throated diver (BEIS, 2022a&b). This indicates that the Competent Authority is of the view that in combination operational displacement from OWFs is already at levels which constitute an adverse effect on the conservation objectives of the Outer Thames Estuary SPA, specifically in relation to the conservation objective concerned with the distribution of the red-throated diver qualifying feature within the site.

1197. As set out in the offshore ornithology PEIR Chapter 13 Volume I (Section 13.6.2.1), displacement is defined as ‘a reduced number of birds occurring within or immediately adjacent to an offshore windfarm’ (Furness et al. 2013) and involves birds present in the air and on the water (SNCB 2017). Birds that do not intend to utilise a OWF site but would have previously flown through the area on the way to a feeding, resting or nesting area, and which either stop short or detour around an OWF site, are subject to barrier effects (SNCB 2017). For the purposes of assessment of birds present in an OWF site during a given season, it is usually not possible to distinguish between displacement and barrier effects - for example to define where individual birds may have intended to travel to, or beyond an OWF site, even when tracking data are available. Therefore, in this assessment the effects of displacement and barrier effects on non-breeding red-throated diver are considered together.

1198. It is considered that no adverse effect on the SPA population of red-throated divers is likely during the construction and decommissioning phases of the project (array areas and offshore cable corridor), due to the temporary nature of construction and decommissioning activities. However, an appropriate assessment of displacement / barrier effects during construction and decommissioning will be presented in the RIAA which accompanies the DCO submission for North Falls.

7.2.3.1.1 Status

1199. At classification, the non-breeding red-throated diver population of the SPA was cited as 6,466 individuals, based on visual aerial surveys between 1989 and 2007 (Natural England and JNCC 2010, 2015). This was the mean of annual counts over the survey period, with respective minimum and maximum counts of 2,460 and 10,884 individuals recorded during this time (APEM, 2013; Irwin et al. 2019).

1200. Recently repeat surveys of the SPA have been undertaken using digital aerial methods, the current standard methodology for offshore ornithology surveys. The SPA population estimate has been revised to 18,079 individuals (Natural England 2019c), which is the 2 year peak mean based on surveys in 2013 (APEM 2013) and 2018 (Irwin et al. 2019). This represents an 180% increase compared with the population estimate at the time of SPA classification. Natural

England (2019) state that '*these increases are thought to reflect improved survey methods and techniques, namely the use of digital aerial surveys, which has provided more accurate counts and suggests that previous counts* [from visual aerial surveys] *have been significant underestimates*'. From the recent SPA surveys, the peak estimate of the red-throated diver population was 22,820 individuals from a survey on 17 February 2018, which represented a 68% increase on the peak count of 13,605 individuals for the period 9-12 February 2013, from the 2013 survey. However, during the 2018 surveys the entire SPA was flown in a single day, whereas in 2013 each survey took place over 2-3 days, so movements of birds between component flights of surveys could have affected the estimates produced by the 2013 surveys.

1201. It is not clear whether the methodology changes, from visual to digital aerial surveys, and the period of time over which surveys were flown, account for all the differences between the 1989-2007 estimate and the 2013 and 2018 estimates, or whether there has been a real increase in the red-throated diver population over this period. Visual aerial surveys of the Outer Thames area for the purposes of estimating densities and defining the SPA boundary, were carried out from planes flying transects at 76m (250ft) above the sea surface (O'Brien et al 2012). Bird records (species and numbers) on and flying above the sea were recorded by two observers on either side of the aircraft. Digital aerial surveys involve the use of still or video cameras fixed to the underside of a plane which are used to record images of birds on and flying above the sea. Digital aerial surveys are also flown in transects but at a higher altitude than visual aerial surveys, with a recommended minimum height of 450m to avoid disturbance to birds (Thaxter and Burton 2009). Visual aerial surveys are considered likely to underestimate numbers of birds at sea, due to the potential for observers to miss some birds and disturbance to birds from the low-flying aircraft (Thaxter and Burton 2009). Natural England (2021) refers to a 2010 study by APEM (cited but no reference provided) indicating that the number of birds recorded by digital aerial stills may be up to 6.5 times that by observers.

1202. It is noted that the population estimate for the Outer Thames Estuary SPA exceeds current estimates of the total numbers of red-throated divers in UK offshore waters during the non-breeding period, respectively 15,371 individuals during winter and 17,650 during spring and autumn migration seasons (Furness 2015).

1203. Natural England (2019) supplementary advice on conservation objectives for the Outer Thames Estuary SPA includes the following targets for red-throated diver which are considered relevant to the appropriate assessment:

- Maintain the size of the non-breeding population at a level which is at or above 18,079 individuals, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent,
- Reduce the frequency, duration and / or intensity of disturbance affecting roosting, foraging, feeding, moulting and/or loafing birds so that they are not significantly disturbed,
- Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other

measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.

7.2.3.1.2 Connectivity and seasonal apportionment of potential effects

1204. Red-throated divers are only present in the SPA during the non-breeding season, defined as September to April, and subdivided into Autumn migration (September to November), winter (December and January) and Spring migration (February to April) (Furness 2015). Thus, the appropriate assessment considers this period only.

1205. Red-throated divers migrate northwards to breed, nesting on the shoreline or islands within small waterbodies in moorland, tundra or boreal forest environments. Available evidence indicates that individuals wintering in the southern North Sea, including the Outer Thames Estuary, breed in Fennoscandia and Russia (MacArthur Green and RHDHV 2021a, Furness 2015).

1206. The array areas are located 2.3km from the Outer Thames Estuary SPA at the nearest point. At this distance there is the potential for displacement effects to red-throated divers to occur within the SPA boundary.

7.2.3.1.3 Effect: Displacement / barrier effect during operation

1207. As set out in PEIR Chapter 13 Volume I (Section 13.6.2.1), the appropriate assessment assumes that a proportion of the birds recorded during baseline surveys would be subject to displacement from the array areas and that a proportion of displaced birds would die as a result of displacement. The proportion of red-throated divers displaced is based on evidence from empirical studies of red-throated diver responses to OWFs; further background on this is provided below. There is no robust empirical evidence to predict the number of displaced divers which might die so the assessment considers a range of 1-10% mortality, based on advice from Natural England, and identifies what is considered to be the most likely proportion based on expert judgement of what is considered to be biologically plausible (see below).

1208. Post-construction monitoring studies of OWFs have shown that displacement effects on red-throated diver can occur at considerable distances from OWFs. The joint (UK) SNCBs (2022) advice on displacement of red-throated diver includes a summary of studies from OWFs in the UK, Danish and German North Sea, indicating displacement extending from 0-2km to 20km from the array areas of an OWF. These studies report that 55-100% (mean of 86% based on 8 studies) of birds are displaced within the array area of an OWF, and provide evidence that the proportion of red-throated divers displaced declines with distance from the OWF with, for example, displacement rates reducing to 12.6% at a distance of 11.5km from the London Array (APEM 2021). Unsurprisingly, the evidence for declining rates of displacement with increasing distance from OWFs derives mainly from those studies which consider effects over more extensive distances from OWFs.

1209. Based on this summary of the available studies, SNCBs (2022) advise that a displacement buffer of at least 10km should be used for impact assessments where a plan or project is within 10km of an SPA designated for non-breeding red-throated diver. Specifically for North Falls, Natural England has advised for HRA that displacement effects be considered out to 12km from the array areas, for those areas where this 12km buffer overlaps with the Outer Thames Estuary

SPA. This is based on the findings from post-construction monitoring at the London Array OWF (APEM 2021), within the SPA, which indicated that displacement effects (reduced densities of red-throated divers post-construction compared with pre-construction) were detectable out to 11.5km from the array areas.

1210. It is unknown why red-throated divers show such large displacement distances from OWFs. It has been suggested that these might reflect distances moved away from OWFs to alternative areas of preferred habitat (McGregor et al. 2022), rather than avoidance of extensive areas around OWFs per-se, which could result in variation in displacement distances between areas and in different directions from a given OWF. Mendel et al. (2019) comment that displacement may not be a result of visual cues (a bird sitting on the sea surface may not be able to see a wind farm array at a distance of 10 or 12km); whilst OWFs may enhance mixing in the water column with ecosystem effects manifesting 10-20km from the OWF, which is of a scale similar to red-throated diver displacement distances identified in some studies. However, the potential mechanisms for such an effect are not clear, nor the reasons why they might affect red-throated divers and apparently not other seabird species over such large distances.

1211. While OWFs and other anthropogenic activities have demonstrable displacement effects on red-throated divers, it is unclear how these might interact with other drivers of the non-breeding season distribution of this species offshore, of which habitat and prey availability must be of primary importance. The post-construction monitoring study (which compared densities and distribution between the pre and post-construction periods) at the London Array found that prior to construction of the OWF, there was a pattern of diver density increasing with distance from the array area up to 9km and then decreasing (APEM 2021). This suggests that preferred habitat for divers across the whole study area occurred outside of the array area footprint, and that the displacement effects from the OWF could be considered in the context of an existing gradient in density for the species.

1212. In terms of the potential effects of displacement on the survival rates of red-throated divers during the non-breeding season, a recent review (MacArthur Green 2019) considered that displacement could influence the survival of individual red-throated divers through increased energy costs and/or decreased energy intake. The former could arise if birds had to fly / travel further to avoid OWFs or to reach more distant foraging areas. The latter could arise if birds were displaced to lower quality habitat where food capture rates were reduced, and/or if displacement resulted in localised increases in the density of divers and, hence, increased intra-specific competition for food. Alternatively, displacement may have no effect on individuals if birds are displaced into equally good habitat so that their energy budget is unaffected, or if birds could buffer any impact on energy budget by adjusting their time budget (for example by spending a higher proportion of the time foraging rather than resting in order to compensate for an increase in energetic costs). Considering the range of 1-10% mortality advised by Natural England, it was concluded that a 1% mortality rate for displaced birds is an appropriate precautionary estimate. This is for a number of reasons: red-throated divers appear to utilise a range of offshore habitats and prey species and occur at relatively low densities rather than in large aggregations; they are also highly mobile during the non-breeding season. This flexibility in diet and habitat use indicates displacement from OWFs is unlikely to result in inter-specific competition for prey that might deplete prey resources and affect body condition and survival. The adult mortality rate is estimated at 16% per annum, which will include mortality from existing anthropogenic sources of disturbance and displacement such as shipping traffic. As red-throated divers tend to fly away from approaching ships, it is likely that the energy costs of this behaviour exceed the costs of avoiding fixed structures such as OWFs. Thus it seems biologically implausible that OWF displacement would add substantially to the existing mortality rate of this species. This is supported by long-term studies of red-throated (and black-throated) divers in the German North Sea, where no changes in the overall population size during spring migration have been found over the period 2001-2021, despite the construction of 20 OWFs (Vilela et al. 2021, 2022). Although the divers changed their distribution, away from the OWFs, the population size remained stable, suggesting no or minimal consequences of mortality for displaced birds. Similarly for the Outer Thames Estuary SPA, there is no evidence of population decline since the SPA was classified in 2010; the population estimate has increased by 180% during the period that five OWFs (including extensions) have been construction and become operational within 12km of the SPA (although as explained above, given the change in survey techniques it is not possible to say whether there has been a genuine increase over this period).

7.2.3.1.3.1 Project alone assessment

1213. The assessment considers the area of the Outer Thames Estuary that overlaps with a 12km buffer from the southern array areas of North Falls), comprising a total area of approximately 149 km^2 (Figure 7.1)[10]. This represents 3.8 % of the total area of the Outer Thames Estuary SPA. This area, where displacement may affect the numbers and distribution of red-throated divers within the SPA boundary, has been divided into 1km increments. It is noted that this area also overlaps with an international shipping lane (outline of ship routing measures shown in Figure 7.1, AIS shipping density data shown in Figure 7.2). Divers are known to be displaced by ships (Mendel et al. 2019, Schwemmer et al. 2011, Bellebaum et al. 2006)), so birds using this area will already be subject to displacement effects from shipping lanes as is suggested from the density distribution maps of red-throated divers in the 2018 surveys (Irwin *et al.* 2019). In the German North Sea, Mendel et al. 2019 modelled the effects of OWFs and ships on red-throated diver displacement. Separating out the effects of both, they found that ships had a strong negative impact on diver abundance within

[10] There is also a very small (approx. 4km^2) overlap of the 12km buffer of North Falls northern array area with the Outer Thames Estuary SPA (Figure 7.1). However, in this area North Falls is more than 10km from the SPA boundary. SNCB (2022) advises that where an OWF is more than 10km from an SPA for non-breeding red-throated diver, displacement within the SPA does not need to be considered, and the displacement gradient provided by Natural England extends to 10km only. Thus, this area is not included in the assessment on the basis that displacement effects from North Falls will be negligible.

5km, although it was not possible to predict the reduction in densities associated with ships independently of those from OWFs.

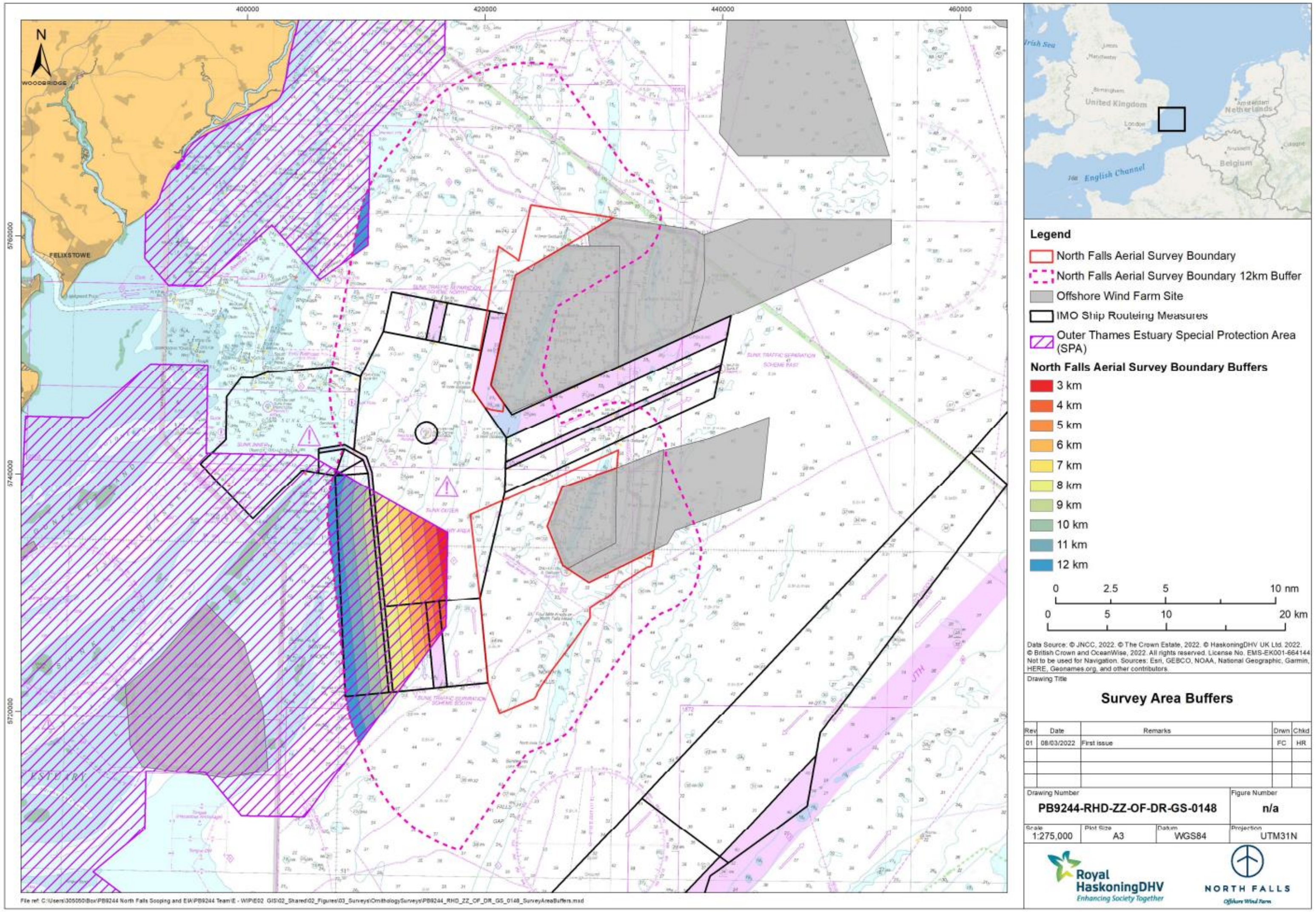

Figure 7.1 Overlap of the 12km buffer from the North Falls array areas and the Outer Thames Estuary SPA

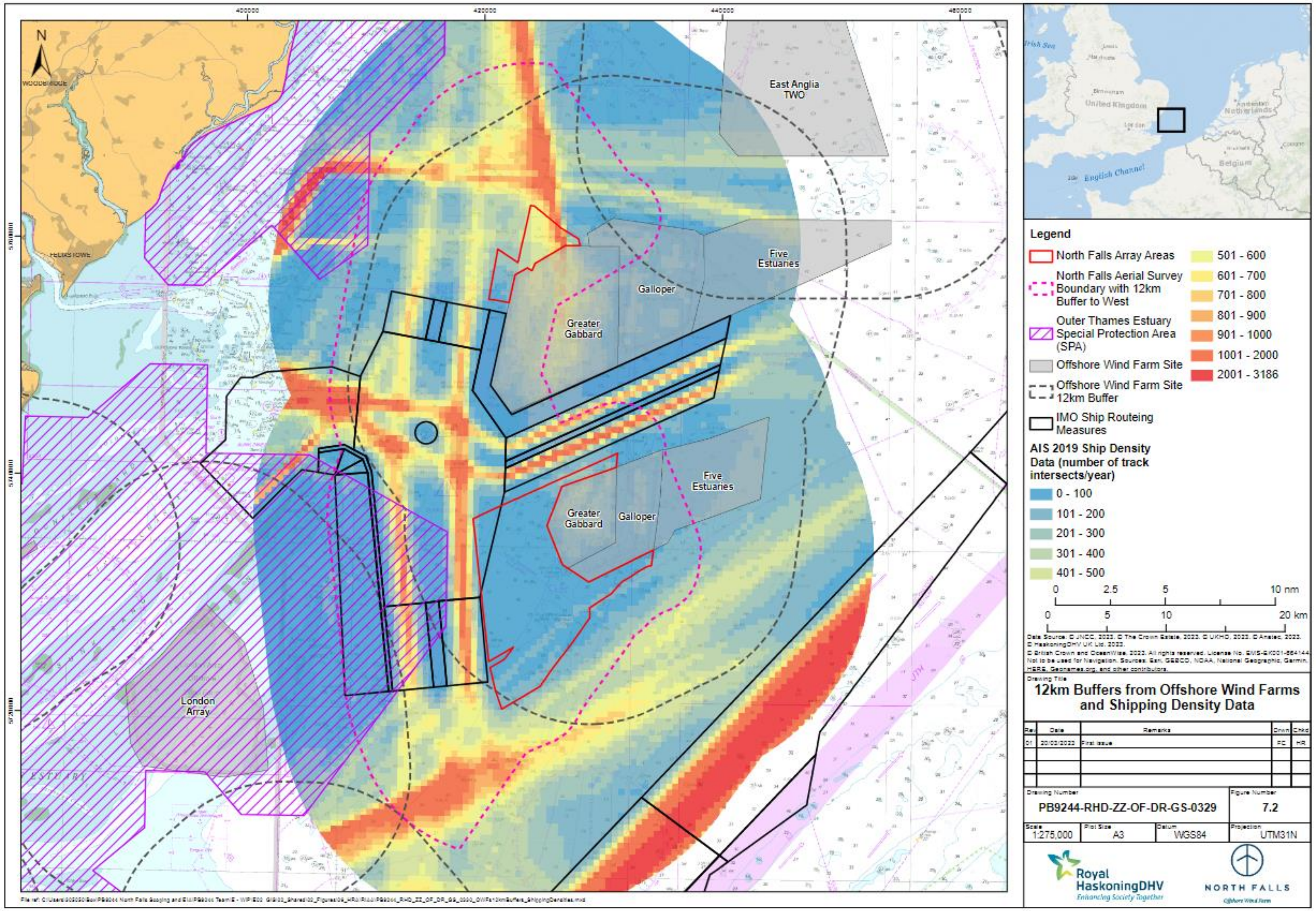

Figure 7.2 Overlap of the 12km buffer from the North Falls array areas with AIS shipping density data and the 12km buffers of other OWFs

1214. Natural England initially advised that red-throated diver displacement from North Falls should be estimated based on a straight-line gradient from 100% displacement within the array areas and a 0-1km buffer from the boundary, to 0% at 12km. The 12km distance is understood to reflect the distance out to which displacement effects were detected during post-construction monitoring at the London Array OWF (APEM 2021). Subsequently this advice was revised to a gradient of predicted decreasing displacement rates for 1km buffers out to 10km, rather than 12km, from an OWF (Table 2, Natural England, 2022b). Within the array areas, a precautionary 100% displacement was applied, as per previous advice. Outside the array areas, the updated advice is based on a linear trend line applied to the precautionary maximum displacement in 1km buffers from calculated displacement gradients from empirical studies. The data used to inform the gradient is from studies at Gunfleet Sands, Kentish Flats, Lincs, Lynn and Inner Dowsing, London Array and OWFs in the German Bight. Natural England advised that this displacement gradient had been provided to Round 4 OWF developers in the Irish Sea, although it was not agreed with other SNCBs.

1215. The assessment for North Falls uses the Natural England (2022) advised gradient to estimate the number of red-throated divers likely to be displaced in those parts of the sequential 1km buffers out from North Falls which overlap with the SPA (based upon applying the advised displacement rates to the estimated number of birds within each 1km buffer section – see below). These areas are shown in Figure 7.1 above. An alternative gradient of displacement rates is also applied for comparative purposes, based on the proportions of birds displaced within the array area and at increasing distance from the OWF, as reported in the post-construction monitoring at the London Array OWF (APEM 2021, Table 5, page 347). The London Array results are used for this purpose as the monitoring at this OWF provides the most detailed data on displacement of red-throated divers from an OWF within the Outer Thames Estuary SPA and from a location very close to North Falls (see Section 7.2.3.1.3.2). The London Array monitoring is one of the few UK studies to date to investigate displacement from OWFs to distances of 12km and beyond. The London Array displacement proportions for red-throated diver were reported in 0.5km increments, from which an average value for each successive 1km buffer was calculated (Table 7.3).

1216. Population estimates of red-throated diver for the area of overlap between the 12km buffer of North Falls and the Outer Thames Estuary SPA were modelled using an Integrated Nested Laplace Approximation (INLA) approach (Appendix 2). The model was used to generate mean density estimates (with associated confidence intervals) for each 1km buffer within the overlap zone of the southern array area and the SPA (Figure 7.1). These were then multiplied by the area of the buffer to obtain the required abundance estimates.

1217. Survey data for the overlap area were available for January and February 2021, from baseline surveys for North Falls (when the baseline survey area was extended to 12km to the west of the array areas, Appendix 13.2 Volume III); and on two days (4th and 17th) in February 2018, from surveys of the Outer Thames Estuary SPA commissioned by Natural England (Irwin et al. 2019). The intention in 2018 was to fly one survey in late January and one in mid-February, but weather and military restriction issues meant this was not possible (Irwin et al. 2019). The winter and spring migration periods were identified for the extended displacement surveys at North Falls, and for surveys for SPA population estimates, because numbers of red-throated divers in this area are highest at this time (Webb et al. 2009). Thus, over the two years of baseline surveys for North Falls, red-throated diver was recorded within the core survey area (i.e. the array areas plus 4km buffer) in small numbers in only one of the surveys undertaken during the autumn migration period (September to November, inclusive - Furness 2015), with the survey data indicating that January and February is the period of peak abundance (PEIR Appendix 13.2 (Volume III), Table A2.17).

1218. Density estimates were modelled separately for each individual survey, thus giving four estimates of abundance for each 1km buffer within the SPA overlap area. Abundance estimates for this area were therefore available for one survey (January 2021) during the winter period (December and January), and three surveys (February 2018 and 2021) during the spring migration period (February to April) (Furness 2015). However, for the purposes of displacement analysis for the assessment, given that the first of the 2018 surveys was flown very early in February, this survey has been allocated to the winter period.

1219. Modelled population abundance estimates for red-throated divers within the area of overlap of the 12km buffer of North Falls and the Outer Thames Estuary SPA, for the winter and spring migration periods in 2018 and 2021 are shown respectively in Table 7.3 and Table 7.4. These are given for the individual 1km buffers from North Falls, and the combined area. For the combined area, the predicted abundances in each month were considerably higher in 2021 than in 2018, suggesting interannual variation in the numbers of birds using this area. In 2021 the predicted number of birds was considerably higher in February than in January, whereas in 2018 the predicted abundance was slightly higher in early February than late February.

1220. The number of red-throated divers predicted to be displaced within the SPA overlap area was estimated as the sum of the proportion of birds predicted to be displaced within each 1km buffer from North Falls, based first on the Natural England and secondly the London Array displacement gradients, multiplied by the abundance estimate for each buffer (Table 7.3 and Table 7.4). The predicted annual displacement mortality, assuming 1-10% mortality of displaced birds, was summed for each of the winter and spring migration periods and expressed as a percentage increase in the baseline annual mortality rate of the SPA population (i.e. in the absence of any wind farm effects). For this purpose, an average annual mortality rate across age classes of 0.228 was used (Horswill and Robinson 2015, see PEIR Chapter 13 Volume I, Table 13.13).

1221. The predicted increases in the mortality rate of the SPA population of red-throated divers due to displacement from North Falls are shown in Table 7.10. Separate estimates are included for scenarios of 1 and 10% mortality of displaced birds, based on the predicted annual mortality due to displacement in 2018, 2021 and a mean of the two years. As discussed previously (paragraph 1212), a recent review of the biologically plausible mortality that could result from displacement effects during the non-breeding period on this species, concluded that 1% mortality of displaced birds is an appropriate precautionary estimate for red-throated diver. Based on this, the maximum predicted increase in the SPA mortality rate for red-throated divers at North Falls is 0.04% (Table 7.10). This magnitude of increase in mortality would not materially alter the background mortality of the SPA population and would be undetectable. Even for scenarios of 10% mortality of displaced birds (considered to be unrealistically high), the maximum predicted increase in mortality would only be 0.35%, which would also not be detectable at a population level.

1222. It is concluded that displacement from North Falls alone would not have an adverse effect on the size of the Outer Thames Estuary SPA non-breeding population of red-throated diver and would not undermine the Natural England target to maintain the size of the non-breeding population at a level which is at or above 18,079 individuals, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.

1223. The project alone assessment also considers the effect of North Falls on the distribution of red-throated divers within the SPA. Natural England has requested that the assessment considers the extent of the SPA where red-throated divers would be subject to some level of displacement (the area of overlap with OWFs and 12km buffers), and the extent of effective displacement (the area of overlap weighted by the predicted proportion of birds displaced at different distance from OWFs).

Table 7.3 Displacement of red-throated divers (RTD) within the overlap of North Falls 12km buffer and the Outer Thames Estuary SPA, winter period

Buffer distance North Falls (km)	Area of SPA overlap (km^2)	% RTD displaced[1]		Number of RTD[2]			No. RTD displaced Natural England gradient[3]			No. RTD displaced London Array gradient[3]		
		Natural England gradient	London Array gradient	Early Feb 18	Jan 21	Mean	Early Feb 18	Jan 21	Mean	Early Feb 18	Jan 21	Mean
0 (within OWF)	0	100%	55%	0	0	0	0	0	0	0	0	0
0 -1	0	80%	46%	0	0	0	0	0	0	0	0	0
1 - 2	0	74%	40%	0	0	0	0	0	0	0	0	0
2 – 3	3.62	68%	41%	1	0	1	1	0	0	0	0	0
3 - 4	9.38	63%	38%	2	1	1	1	1	1	1	0	1
4 - 5	11.18	57%	32%	2	1	2	1	1	1	1	0	1
5 - 6	12.92	51%	34%	2	2	2	1	1	1	1	1	1
6 - 7	14.65	46%	36%	2	4	3	1	2	1	1	1	1
7 - 8	16.36	40%	41%	3	6	4	1	2	2	1	2	2
8 - 9	18.02	34%	45%	3	9	6	1	3	2	1	4	3
9 - 10	19.59	29%	42%	5	13	9	1	4	3	2	6	4
10 - 11	21.1	0%	29%	7	17	12	0	0	0	2	5	4
11 - 12	22.62	0%	3%	9	21	15	0	0	0	0	1	0
Totals	149.4			36	75	55	9	13	11	10	20	15
Predicted mortality of displaced RTD at 1%							0	0	0	0	0	0
Predicted mortality of displaced RTD at 10%							1	1	1	1	2	2
1. The predicted number of RTDs displaced within an OWF and successive 1km buffers out to 12km, based on the gradient provided by Natural England, and the post-construction monitoring study of the London Array OWF (LA). 2. The modelled abundance of RTDs within successive 1km buffers of North Falls where they overlap with the Outer Thames Estuary SPA, derived from Appendix 2. 3. The number of RTDs predicted to be displaced within each 1km buffer, based on the Natural England and London Arraygradients.												

Table 7.4 Displacement of RTD within the overlap of North Falls 12km buffer and the Outer Thames Estuary SPA, spring migration

Buffer distance North Falls (km)	Area of SPA overlap (km^2)	% RTD displaced[1]		Number of RTD[2]			No. RTD displaced Natural England gradient[3]			No. RTD displaced London Array gradient[3]		
		Natural England gradient	London Array gradient	Feb 18	Feb 21	Mean	Feb 18	Feb 21	Mean	Feb 18	Feb 21	Mean
0 (within OWF)	0	100%	55%	0	0	0	0	0	0	0	0	0
0 -1	0	80%	46%	0	0	0	0	0	0	0	0	0
1 - 2	0	74%	40%	0	0	0	0	0	0	0	0	0
2 – 3	3.62	68%	41%	0	5	3	0	3	2	0	2	1
3 - 4	9.38	63%	38%	0	16	8	0	10	5	0	6	3
4 - 5	11.18	57%	32%	1	25	13	0	14	7	0	8	4
5 - 6	12.92	51%	34%	1	36	18	0	18	9	0	12	6
6 - 7	14.65	46%	36%	1	43	22	0	20	10	0	15	8
7 - 8	16.36	40%	41%	1	48	25	1	19	10	1	19	10
8 - 9	18.02	34%	45%	2	50	26	1	17	9	1	22	12
9 - 10	19.59	29%	42%	3	52	27	1	15	8	1	22	11
10 - 11	21.1	0%	29%	4	53	29	0	0	0	1	16	8
11 - 12	22.62	0%	3%	7	57	32	0	0	0	0	2	1
Totals	149.4			20	384	202	4	117	60	5	124	65
Predicted mortality of displaced RTD at 1%							0	1	1	0	1	1
Predicted mortality of displaced RTD at 10%							0	12	6	1	12	6
1. The predicted number of RTDs displaced within an OWF and successive 1km buffers out to 12km, based on the gradient provided by Natural England, and the post-construction monitoring study of the London Array OWF . 2. The modelled number of RTDs within successive 1km buffers of North Falls where they overlap with the Outer												

Buffer distance North Falls (km)	Area of SPA overlap (km²)	% RTD displaced[1]		Number of RTD[2]			No. RTD displaced Natural England gradient[3]			No. RTD displaced London Array gradient[3]		
		Natural England gradient	London Array gradient	Feb 18	Feb 21	Mean	Feb 18	Feb 21	Mean	Feb 18	Feb 21	Mean

Thames Estuary SPA, derived from Appendix 2.3 (Volume III). The number of RTDs predicted to be displaced within each 1km buffer, based on the Natural England and London Array gradients.

Table 7.5 Predicted annual displacement mortality of red-throated divers (RTD) within the overlap of North Falls 12km buffer and the Outer Thames Estuary SPA and effect on population mortality rate

Year	2018		2021		Mean 2018 and 2021	
	Natural England displ. gradient	London Array displ. gradient	Natural England gradient	London Array gradient	Natural England gradient	London Array gradient
Predicted annual displacement						
No. of RTDs	13	15	130	144	71	80
Predicted annual displacement mortality (number of RTD)						
1% mortality of displaced birds	0	0	1	1	1	1
10% mortality of displaced birds	1	2	13	14	7	8
Predicted % increase in population mortality rate[1]						
1% mortality of displaced birds	0.00	0.00	0.03	0.04	0.02	0.02
10% mortality of displaced birds	0.03	0.04	0.32	0.35	0.17	0.19
1. Based on an SPA population of 18,079 non-breeding individuals of all age classes and an average annual mortality rate across age classes of 0.228						

1224. The displacement area where the 12km buffer of North Falls overlaps with the SPA encompasses 149.4km^2, representing 3.8% of the SPA area (Table 7.6). The effective displacement area, based respectively on the Natural England and London Array displacement gradients is 46.42 km^2 and 48.14 km^2, both equivalent to 1.2% of the SPA area.

1225. Where it overlaps with the SPA boundary, the 12km buffer of North Falls overlaps in turn with 12km buffers of the London Array OWF and GGOW (Figure 7.3). The area where displacement effects would be predicted for North Falls alone is 70.3km^2 (i.e. excluding those areas already potentially affected by displacement from existing OWFs), equivalent to 1.8% of the SPA area. Given this overlap, the effective displacement area from North Falls alone would be less than 1% of the SPA area.

1226. Also, as noted previously, this area of overlap between the 12km buffer of North Falls and the SPA also overlaps almost completely with an International Maritime Organisation (IMO) international shipping lane (Figure 7.1 and Figure 7.2). The IMO areas within the SPA overlap area are, from west to east, the Long Sands two-way route, a narrow Traffic Separation Zone, and the Sunk Outer Precautionary Area and Sunk South Traffic Separation Lanes. Vessel density data for this area for the 12 month period March 2019 to February 2020 (pre-COVID19) are presented in Figure 7.2. These show the highest densities in two lanes, one immediately to the west of the North Falls southern array area and east of the Outer Thames Estuary SPA boundary, and another parallel high density area further to the west, overlapping with the Outer Thames Estuary SPA boundary and the 12km buffer from North Falls. These high density lanes areas pass through the Sunk South Traffic Separation Lanes and the Sunk Outer Precautionary area.

1227. Overall, considering the total area of overlap between the 12km buffer of North Falls and the Outer Thames Estuary SPA, only 1.5km^2 of this area (i.e. 0.5% of the SPA area) does not overlap with the existing sources of displacement for red-throated divers which arise from the 12km buffers associated with another OWFs and/or IMO shipping measures (Figure 7.2). This small area of overlap of the North Falls 12km buffer with the SPA where only effects from North Falls would be likely, is also at the outer edge of the 12km buffer of the array areas, where displacement effects due to North Falls are predicted to be much reduced compared with areas closer to the arrays.

1228. On this basis it is considered that North Falls would not contribute significantly to the existing sources of disturbance/displacement for red-throated divers in this area and that a Project alone effect on the distribution of the species within the SPA can be excluded.

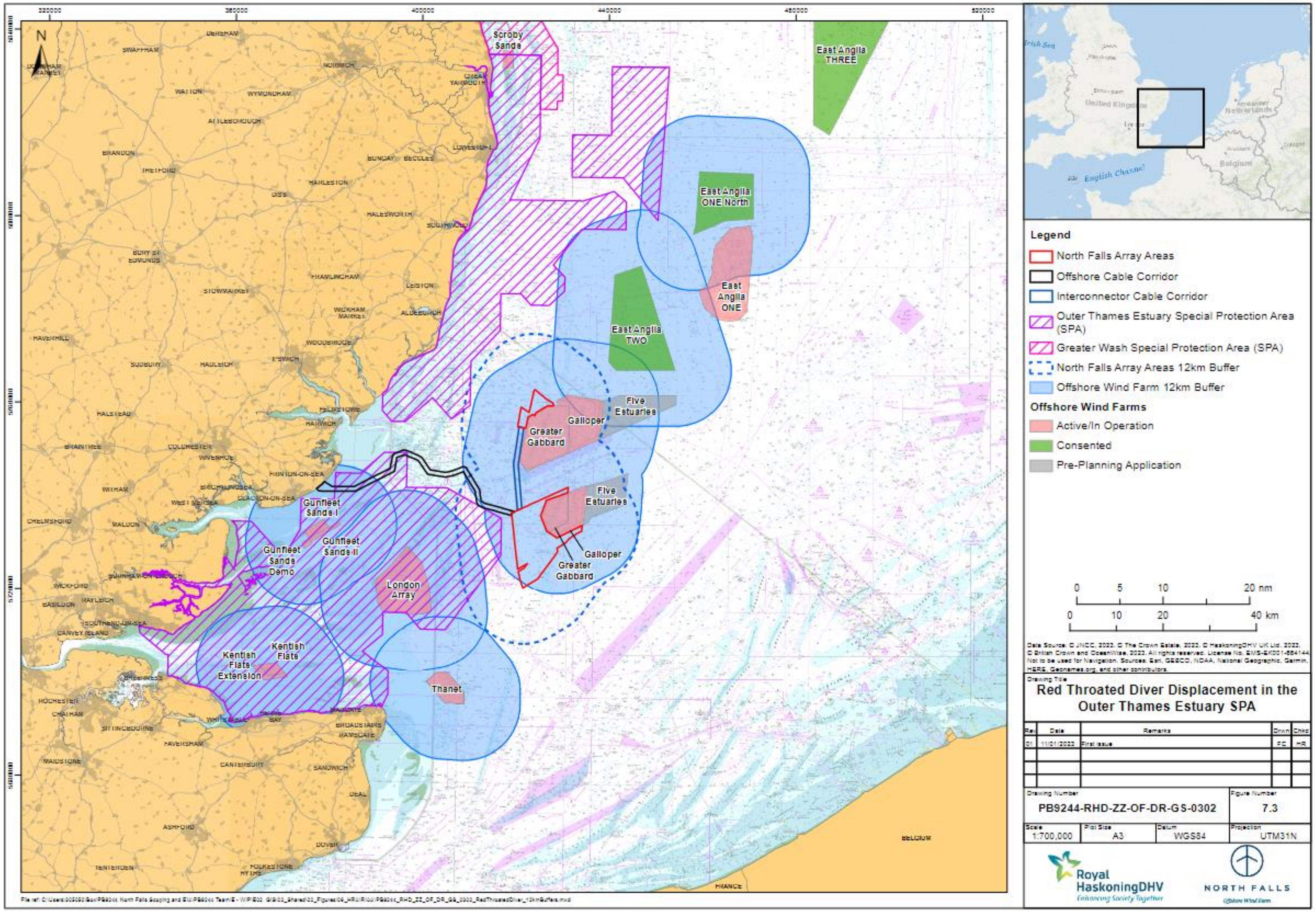

Figure 7.3 Offshore wind farm 12km buffers

Table 7.6 Displacement area and effective displacement area of red-throated divers (RTD) within the overlap of North Falls 12km buffer and the Outer Thames Estuary SPA

Buffer Distance North Falls (Km)	Area Of SPA Overlap (Km^2)	% RTD Displaced[1]		Effective Displacement Area (Km^2)[2]	
		Natural England Gradient	London Array Gradient	Natural England Gradient	London Array Gradient
0 (within OWF)	0	100%	55%	0	0
0 -1	0	80%	46%	0	0
1 - 2	0	74%	40%	0	0
2 – 3	3.62	68%	41%	2.46	1.48
3 - 4	9.38	63%	38%	5.91	3.56
4 - 5	11.18	57%	32%	6.37	3.58
5 - 6	12.92	51%	34%	6.59	4.39
6 - 7	14.65	46%	36%	6.74	5.27
7 - 8	16.36	40%	41%	6.54	6.71
8 - 9	18.02	34%	45%	6.13	8.11
9 - 10	19.59	29%	42%	5.68	8.23
10 - 11	21.1	0%	29%	0.00	6.12
11 - 12	22.62	0%	3%	0.00	0.68
Totals	149.44			46.42	48.14
% of SPA[3]	3.8 %			1.2 %	1.2%

1. Displacement gradients from Natural England, and the post-construction monitoring study of the London Array OWF .

2. Effective displacement is the area of SPA overlap for a given buffer multiplied by the % of red-throated divers (RTD) predicted to be displaced. The total SPA area is $3924km^2$.

7.2.3.1.3.2 In combination assessment

1229. The in combination assessment considers the potential displacement effects of North Falls OWF in combination with other OWFs within or close to the boundary of the Outer Thames Estuary SPA. Natural England has advised that the following OWFs are considered (for operational sites, the year of full commissioning is given):

- London Array (2013),
- Gunfleet Sands I, II and III (2010),
- Kentish Flats 2005) and Extension (2015),
- GGOW (2013),
- Thanet (2010),
- East Anglia ONE North,
- East Anglia TWO.

1230. The locations of these OWFs and North Falls in relation to the SPA are shown in Figure 7.3. The figure also shows 12km buffers from each OWF, as this is the distance that Natural England has advised for consideration of displacement effects (noting that it is a single combined 12km buffer area that is shown for each of Gunfleet Sands I, II and III, Kentish Flats and Extension, and also for GGOW and GWF, as it is considered that these would be perceived by red-throated divers as effectively one OWF).

1231. Baseline surveys of other OWFs included in the in-combination assessment pre-date the most recent evidence on the extent of displacement effects of OWFs on red-throated diver, and do not cover areas out to 12km from each OWF. Therefore, estimates specific to each OWF of the number of red-throated divers likely to be displaced within 12 km, are not available for in combination assessment.

1232. During the DCO examination for East Anglia ONE North and TWO, a model of red-throated diver displacement from OWFs within the Outer Thames Estuary SPA was developed (MacArthur Green and Royal HaskoningDHV 2021b). This was based on data from both visual aerial surveys flown in 2002-2007 (i.e. as used to identify the SPA boundary for red-throated divers) and digital aerial surveys in 2013 and 2018 (commissioned by Natural England to update the Outer Thames Estuary SPA population estimate for red-throated divers). Thus the red-throated diver data input to the model were from surveys which began before all OWFs were commissioned, continued during construction and the early operational period of some OWFs, and post commissioning of the most recent OWFs in 2013.

1233. The modelling made use of a combination of static covariates (bathymetry, distance to coast and shipping traffic density (MMO)) and a time-varying term, distance to OWF (a time-dependent variable, changing as new OWFs came into operation). The modelled relationship between the explanatory variables and observed red-throated diver usage was used to predict red-throated diver abundance in 1km buffers from East Anglia ONE North and TWO and OWFs within the SPA boundary, with and without OWF displacement effects, for the purpose of in combination assessment. Use of this model was considered during the EPP for North Falls, however Natural England did not endorse its use for the North Falls in combination assessment, due to concerns about aspects of the model (although it would appear to represent the best available evidence on red-throated diver displacement which is specific to the Outer Thames Estuary SPA). These concerns are set out in Natural England (2021b). Although the Applicant for East Anglia ONE North and TWO responded to these concerns (MacArthur Green and Royal HaskoningDHV 2021b), Natural England has advised North Falls that they consider that there are unresolved issues in relation to the extent to which the model reflects empirical evidence relating to the displacement rates of red-throated divers within the array areas of OWFs.

1234. No alternative estimates of the number of red-throated divers displaced within the SPA by the in-combination effects from OWFs are available. As a result, an in-combination total of the potential mortality of red-throated divers from these OWFs, and the consequent predicted change in the mortality rate of the SPA population, cannot be estimated.

1235. Instead, Natural England has advised that the in combination assessment should be carried out based on the area of the SPA where birds are potentially subject to some degree of displacement, and the effective displacement area taking account of decreasing displacement effects with distance from an OWF.

1236. It should be noted that there is no evidence of a decline in the SPA population of red-throated divers since the site was first classified in 2010, and in fact the population estimate has increased by 180% from 6,466 non-breeding individuals for the period 1989-2007, to 18,079 individuals for 2013-2015 (Section 7.2.3.1.1). It is unclear whether the increase is wholly accounted for by the change of survey method between the two time periods, from visual aerial surveys to digital aerial surveys, or whether there has been a real increase in the numbers of red-throated divers present. At the time the SPA was first classified in 2010, Scroby Sands and Kentish Flats OWFs had been operational since 2004 and 2005 respectively, and Gunfleet Sands I and II were in construction (Natural England and JNCC 2010). Since then Gunfleet Sands III, GGOW, London Array and Kentish Flats Extension OWFs have been constructed and commissioned. Thus, although the number of OWFs within and close to the SPA boundary, and displacement effects, have increased, there is no evidence for decline in the SPA population and it is possible that the population has increased. This suggests that the effects of displacement from OWFs have not affected the actual population size of red-throated diver within the SPA. Similarly, in the German North Sea, a long-term study found that the abundance of divers during the spring migration period (when peak numbers of birds were present) remained stable between 2001 and 2021, despite this coinciding with OWF construction in this area expanding from 1 to 20 OWFs between 2009 and 2018 (Vilela et al. 2021), and from 12 WTGs in 2009 to 1,268 in early 2022 (Vilela et al. 2022). There was, however, a marked change in the distribution of divers in this area, such that numbers increased in areas away from OWFs.

1237. A review of the potential effects of displacement on red-throated diver survival reported evidence that populations are limited by availability of suitable breeding habitat (nesting sites within range of foraging areas), rather than competition for resources during the non-breeding season (MacArthur Green 2019).

1238. Given the above, it is concluded that adverse effects on the population size of red-throated diver of the Outer Thames Estuary SPA from in combination displacement from OWFs can be excluded.

1239. Displacement from OWFs may, however, also affect the distribution of red-throated divers within the SPA, by reducing densities in areas within and close to the array areas. As for the project alone, the assessment considers the extent of the SPA where red-throated divers would be subject to some level of displacement (the displacement area), and the extent of effective displacement (the area of overlap weighted by the predicted proportion of birds displaced at different distances from OWFs).

Table 7.7 In combination displacement area and effective displacement area for the Outer Thames Estuary SPA, with and without North Falls

Buffer Distance from Owfs (Km)	Displacement Area (Area of SPA Overlap, Km^2)[1]		% RTD Displaced[2]		Effective Displacement[3] without North Falls (Km^2)		Effective Displacement with North Falls (Km^2)	
	Without North Falls	With North Falls	Natural England Gradient	London Array Gradient	Natural England	London Array	Natural England	London Array
0 (within OWF)	165.61	165.61	100%	55%	165.61	90.56	165.61	90.56
0 -1	90.15	90.15	80%	46%	72.12	41.84	72.12	41.84
1 - 2	103.83	103.83	74%	40%	76.83	41.48	76.83	41.48
2 – 3	117.03	119.31	68%	41%	79.58	47.72	81.13	48.65
3 - 4	131.14	139.93	63%	38%	82.62	49.55	88.15	52.87
4 - 5	141.62	152.40	57%	32%	80.72	45.72	86.87	49.20
5 - 6	150.31	162.81	51%	34%	76.66	51.08	83.03	55.32
6 - 7	162.13	176.32	46%	36%	74.58	58.09	81.11	63.18
7 - 8	154.29	170.10	40%	41%	61.71	62.76	68.04	69.20
8 - 9	165.43	181.78	34%	45%	56.25	74.45	61.80	81.81
9 - 10	176.42	188.41	29%	42%	51.16	73.92	54.64	78.95
10 - 11	185.25	176.96	0%	29%	0.00	54.02	0.00	51.60
11 - 12	196.00	181.88	0%	3%	0.00	5.31	0.00	4.93
Totals	1939.20	2009.47			877.84	696.51	919.33	729.59
% SPA area4	49	51			22	18	23	19

1. Measurements of the overlap between OWF buffers and the SPA take account of areas of overlap between the buffers of more than one OWF, prioritising the OWF which is closest, so no area is counted twice. For the 10-11km buffers, because of the relative positioning of OWFs, the area of overlap is actually larger without North Falls. 2. Gradients provided by Natural England , and the post-construction monitoring study of the London Array OWF . 3. Effective displacement is the area of SPA overlap for a given buffer multiplied by the % of red-throated divers (RTD) predicted to be displaced.4. The total SPA area is 3924km2.

1240. Overlap between the 12km buffers of OWFs and the SPA boundary occurs mostly in the southern component of the SPA (Figure 7.3). This is also the area where red-throated divers were recorded at highest densities in both SPA surveys flown in February 2018 (Irwin et al. 2019). In the 2013 SPA surveys, the highest numbers were recorded in the northern components of the SPA in the January survey, and in the southern component in February (APEM 2013).

1241. The in-combination displacement area and the area of effective displacement are shown in Table 7.7, with and without North Falls. Excluding North Falls, the total area of the SPA within 12km of an OWF is 1939.2 km^2, representing 49% of the total SPA area. Including the overlap of the North Falls 12km buffer with the SPA adds 70.27 km^2, bringing the total to 51% of the SPA. This is the area of the SPA over which red-throated divers are considered to be subject to some degree of displacement from OWFs.

1242. If displacement effects of OWFs were considered to extend out to 10km (rather than 12km) from the boundary, based on the Natural England gradient, the total area of the SPA where there would be some displacement effect would be 1557.95km without North Falls, and 1650.63km with North Falls, respectively 40 and 42% of the SPA area.

1243. The effective displacement area is an estimate of the area effectively lost from the SPA due to predicted displacement within and at varying distances from OWFs (see paragraph 1223 above). Without North Falls, this is estimated at 698.51 km^2 using the displacement gradient from the London Array OWF, and 877.84 km^2 using the gradient advised by Natural England (2022), which accounts for 18 and 22% of the SPA area, respectively. Including North Falls increases these totals to 729.59 and 919.33 km^2, respectively 19 and 23% of the total SPA area (Table 7.7). The additional effects from North Falls only occur from the 2 – 3km buffer outwards, where the displacement rates are predicted to be considerably lower than in areas within and closer to OWFs.

1244. The HRA for East Anglia ONE North OWF (BEIS 2022a) states that before considering the effects of this development, Natural England were concerned that there is already an adverse effect on the Outer Thames Estuary SPA from the displacement of red-throated divers from existing OWFs, and that 31% - 47% of the SPA area was already affected (it is understood that these percentages refer to the displacement area as estimated at the time by the Applicant and Natural England and not the effective displacement area). Natural England advised that a change in the distribution of this species within the SPA was incompatible with meeting the conservation objective to maintain diver distribution and that this would constitute an AEoI of the SPA. The Secretary of State agreed with this advice and concluded that, based on the East Anglia ONE North boundary at the time, which was 2km from the SPA boundary, an adverse effect on the SPA could not be excluded as a result of displacement of red-throated divers from East Anglia ONE North alone and in combination with other OWFs. The development was subsequently consented subject to no WTGs being permitted within 8km from the SPA; and compensation measures comprising: management of vessel traffic for East Anglia THREE and East Anglia ONE OWFs to reduce traffic through the SPA, monitoring red-throated diver distribution within the SPA to determine the extent of red-throated diver redistribution; and the establishment of a red-throated diver compensation steering group to identify and implement opportunities for reducing disturbance effects on this species at a strategic level.

1245. Given the conclusion of the HRA for East Anglia ONE North, it is considered that there is an existing adverse effect on the distribution of red-throated divers in the SPA due to the in combination effects of OWFs.

1246. Importantly, however, North Falls makes a very small contribution to the in combination effect from other OWFs, increasing the displacement area by just 2% and the effective displacement area by 1%, when added to the effects of other existing (operational and consented) OWFs (Table 7.7). Further, as described above, with the exception of an area of just 1.5km^2, all of the overlap between the 12km buffer of North Falls and the SPA also overlaps with existing sources of displacement for red-throated divers - IMO ship-routeing measures and / or the 12km buffer of another OWF (paragraph 1227 above). Added to this, the small area of overlap between the North Falls 12km buffer and the SPA, which is not also overlapping with the buffers from other OWFs or with shipping lanes, is located at the furthest extremity of the buffer zone, where any displacement effects are predicted to be small (Figure 7.2).

1247. It is therefore concluded that North Falls would not contribute to a significant increase in the existing in combination effect of OWFs on the distribution of red-throated divers within the Outer Thames Estuary SPA, and specifically in relation to North Falls, an in-combination effect can be excluded.

1248. Nevertheless, the RIAA presented with the PEIR for North Falls is accompanied by a without prejudice report on potential compensation measures for red-throated divers at the Outer Thames Estuary SPA.

7.3 Alde-Ore Estuary SPA and Ramsar site

7.3.1 SPA overview

1249. Situated on the east Suffolk coast, the Alde Ore Estuary SPA and Ramsar site covers an estuary complex of the rivers Alde, Butley and Ore, including Havergate Island and Orfordness. The SPA supports a variety of habitats for breeding and wintering birds within its boundary, including vegetated shingle, intertidal mudflats, semi-improved grazing marsh, saltmarsh and saline lagoons.

7.3.2 Conservation objectives

1250. The SPA's conservation objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- The extent and distribution of the habitats of the qualifying features;
- The structure and function of the habitats of the qualifying features;
- The supporting processes on which the habitats of the qualifying features rely;

- The populations of each of the qualifying features; and
- The distribution of qualifying features within the site.

1251. Supplementary advice on the conservation objectives for the Alde-Ore Estuary SPA, from Natural England's designated sites view, is referred to in the assessment below.

7.3.3 Shadow Appropriate Assessment

1252. The following qualifying features have been screened in for appropriate assessment (Section 4.4):

- Sandwich tern, breeding
- Lesser black-backed gull, breeding
- Avocet, breeding and non-breeding
- Marsh harrier, breeding
- Redshank, non-breeding
- Ruff, non-breeding
- Assemblage of breeding and wintering wetland birds

1253. At PEIR, a shadow appropriate assessment is presented for lesser black-backed gull only, as the SPA population of this species has been identified by Natural England as one where North Falls is considered to have the potential to contribute to an in combination AEoI, along with other UK OWFS in the North Sea. The RIAA which accompanies the DCO submission will include appropriate assessments for all qualifying features of the Alde-Ore Estuary that have been screened in.

7.3.3.1 Lesser black-backed gull

1254. Lesser black-backed gull has been screened into the shadow Appropriate Assessment in relation to operational collision risk during the breeding and non-breeding season.

7.3.3.1.1 Status

1255. The SPA citation at classification in 1986 does not provide details of the numbers of lesser black-backed gulls present, but states that an internationally important population was present. Supplementary advice on Natural England's designated sites view indicates that the four year peak mean population at the Alde-Ore Estuary SPA 1994-1997 was 14,070 breeding pairs (Seabird Monitoring Programme (SMP) database), numbers increased to a peak of 23,400 pairs in 2000, but then declined substantially with a five year peak-mean 2011-2015 of 1,940 breeding pairs. The primary cause of the decline has been reported to be large-scale abandonment of the colony in response to predation by foxes (Ross-Smith et al. 2014a; Mavor et al. 2001, 2003), with other possible factors including disturbance by Chinese water deer and reductions in fisheries discards (MacArthur Green and Royal HaskoningDHV 2022). The decline has also taken place against a backdrop of large scale immigration of breeding lesser-black backed gulls to urban environments, where productivity is generally higher (Ross-Smith et al. 2014a). Natural England has set a target to restore the size of the breeding population to a level which is above 14,074 pairs, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent. As part of compensation measures agreed for Norfolk Boreas and Norfolk Vanguard OWFs, a 4-5hectare enclosure with predator exclusion fencing is being established at Orfordness, to protect nesting lesser black-backed gulls from predation and disturbance (MacArthur Green and Royal HaskoningDHV 2022).

1256. Trends in the numbers of lesser black-backed gulls breeding at the Alde-Ore Estuary SPA since 2000 are shown in Figure 7.4 (data from SMP (2022), accessed September 2022). This shows nesting numbers at the two colonies within the SPA: Orfordness and Havergate Island.

1257. Counts of breeding lesser black-backed gull within the Alde-Ore SPA, for the most recent 5-year period where data are available from the SMP (2022) database, are shown in Table 7.8. The five-year mean 2015-2019 is 1,853 breeding pairs, or 3,706 breeding adults.

Table 7.8 Most recent five-year counts of breeding lesser black-backed gulls at the Alde-Ore Estuary SPA (from SMP database, accessed September 2022)

Year	Number of breeding pairs of lesser black-backed gull		
	Havergate Island	Orfordness	SPA
2015	2399	60	2459
2016	1668	91	1759
2017	1714	239	1953
2018	1327	97	1424
2019	1670	-	1670
Five year mean			1853

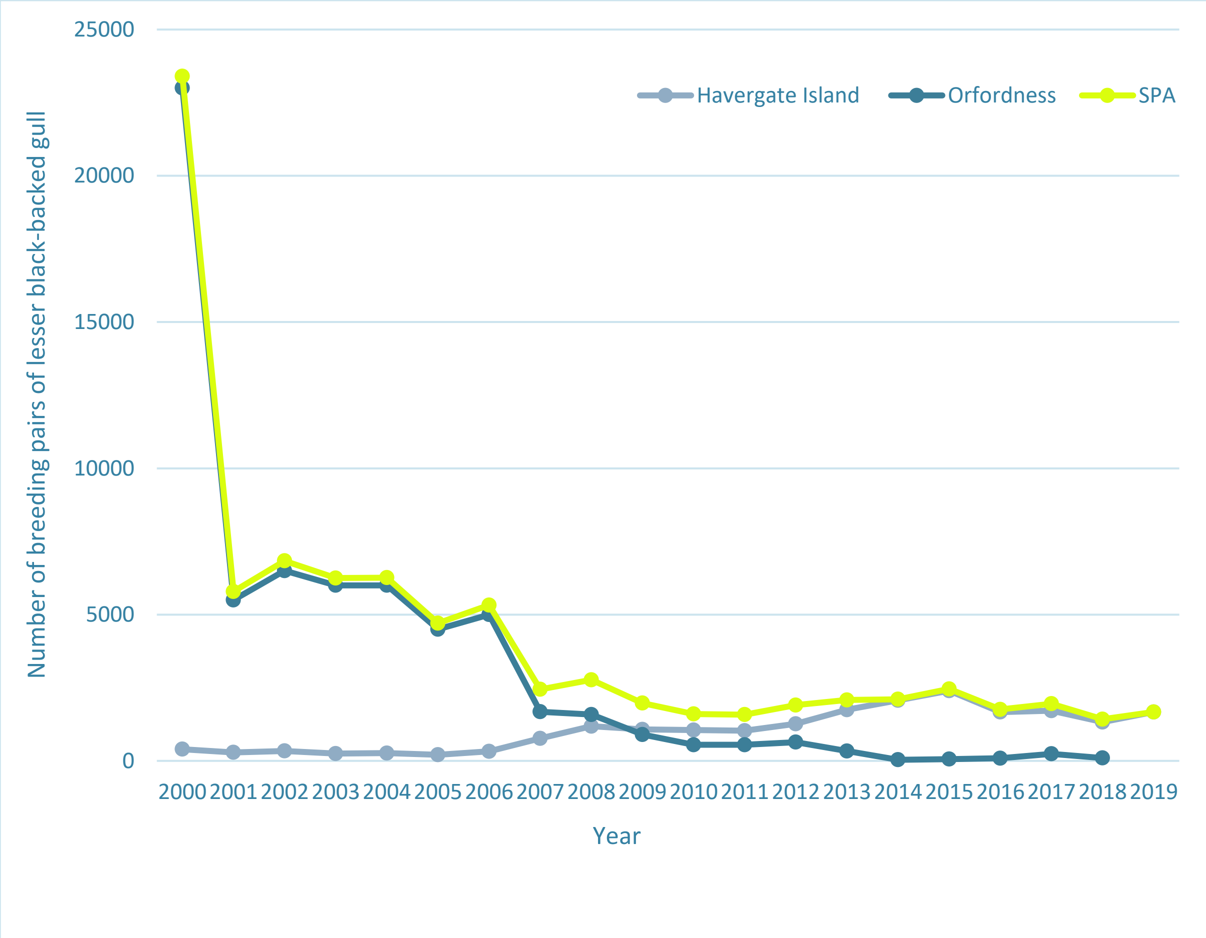

Figure 7.4 Number of breeding lesser-black backed gulls breeding at the Alde-Ore SPA since 2000 (showing the two breeding colonies at Havergate Island and Orfordness separately and the SPA total). Data from SMP (2022) database (accessed September 2022)

7.3.3.1.2 Functional linkage and seasonal apportionment of potential effects

7.3.3.1.2.1 Breeding season

1258. The array areas are situated approximately 22km from the Alde-Ore Estuary at the nearest point. This is within MMFR of lesser black-backed gull (127 ± 109km); reported by Woodward et al. (2019) based on 9 studies involving 18 colonies. A three-year tracking study of lesser black-backed gulls breeding at Orfordness in the Alde-Ore Estuary (Thaxter et al. 2015) indicates that the foraging ranges of tagged birds overlapped with the array areas in only one out of the three breeding seasons encompassed by this study. Birds were tagged after capture at the nest site during early-incubation in 2010 and 2011, and over the three years the study covered the pre-breeding (February to May), breeding (May to July) and post breeding (July to October) periods. The study reported mean offshore foraging ranges (lesser black-backed gulls also forage to a substantial extent in coastal and terrestrial habitats) in 2010, 2011 and 2012 of respectively 33.5 ± 16.1 km (0.4-158.7), 25.1 ± 10.9 km (0.8–124.0) and 14.7 ± 5.7 km (0.4-158.5). Woodward et al. (2019) report mean and maximum foraging ranges for birds breeding at Orfordness of 49.9 km and 124 km based on combined tracking data from the British Trust for Ornithology (BTO) and Royal

Society for the Protection of Birds (RSPB) (which it is assumed includes the data published in Thaxter et al. 2015).

1259. North Falls is not within breeding season foraging range of any other SPA colonies, however there are a number of other (non-SPA) breeding colonies of lesser black-backed gulls within potential foraging range, mostly in urban areas. Recent count data for such sites are not consistently available in the Seabird Monitoring Programme (SMP) database (as of September 2022). However, a survey of Suffolk and south Norfolk in 2012 (Piotrowski 2013) reported an estimated 2,882 pairs in urban sites. A breakdown is given in Table 7.9 below. Gulls nesting in urban environments (often on elevated surfaces such as flat roofs) are more difficult to count accurately than in natural sites (Burnell 2021, Ross et al. 2016), and abnormally wet and cold weather in April and May 2012 was likely to have caused premature failure of some nests, so the estimate from Piotrowski (2013) is likely to be conservative. While these counts are from 10 years ago, given the continuing increase in occupation of urban habitats by nesting lesser black-backed gulls (Burnell 2021), it is assumed that the 2012 data represent at least a minimum estimate of the current urban nesting population in the surveyed area. A review by MacArthur Green of nesting habitats used by lesser black-backed gulls in East Anglia (Royal HaskoningDHV, 2019a) indicated that the Alde-Ore Estuary held about 98% of the regional breeding population in 1985-96, 89% in 2000, and about 31% in 2012-2016; it was acknowledged that gulls breeding in urban areas may be perceived as a nuisance and subject to control measures, but any reductions in numbers may be temporary until birds find alternative urban sites where they are tolerated. Based on surveys for urban nesting gulls in 2019 and 2020, using a new survey methodology, it was estimated that two-thirds to four-fifths of the overall English breeding population of lesser black-backed gulls now nest in towns and cities (although confidence around these estimates is poor), and mapped estimates of mean nesting numbers per 1km square in urban environments indicate several areas of high density in Suffolk and south Norfolk (Burnell 2021). Thus, it seems likely that the percentage of the regional population of lesser black-backed gulls nesting at the Alde-Ore Estuary SPA will have decreased further since 2012-2016.

1260. Lesser black-backed gulls do not forage only or even predominantly at sea, but also in coastal and terrestrial environments, although there is evidence from some studies that breeding adults may spend more time foraging offshore during chick-rearing, perhaps to meet dietary needs of growing chicks (e.g. Thaxter et al. 2015, Royal HaskoningDHV, 2019a). There are relatively few published tracking studies of urban-breeding lesser black-backed gulls. A review of available data, including information from unpublished studies, concluded that urban nesting gulls from some colonies spend time foraging at sea, although it is not clear whether the proportion of time spent at sea is different to that of gulls breeding at natural coastal sites (Royal HaskoningDHV, 2019a). A comparative study of lesser black-backed gulls breeding in urban and natural coastal habitats in Cumbria (Langley et al. 2022) showed that birds from both breeding colonies spent a small proportion of foraging time in marine habitats, in both cases utilising marine areas at lower rates than would be expected compared with their availability within foraging range. The predominant habitats used were agricultural and coastal (coastal nesting birds) and agricultural, coastal and urban (urban nesting birds), with coastal birds apparently showing a preference for coastal habitats, and urban nesting birds a preference for urban and coastal habitats.

1261. Thus, lesser black-backed gulls recorded in the array areas during the breeding season are likely to include birds from the Alde-Ore SPA as well as other non-SPA breeding colonies in Suffolk and south Norfolk.

1262. NatureScot guidance on apportioning impacts from OWFs to breeding colonies (Scottish Natural Heritage, SNH 2018) has been used to estimate the proportion of lesser black-backed gulls from each breeding site likely to occur in the array areas during the breeding season (Table 7.9). The percentage of birds likely to originate from each colony is based on colony, distance and available sea area weightings, calculated as explained in the table notes. Based on this, it is estimated that 59% of birds present in the array areas during the breeding season would be expected to originate from the Alde-Ore SPA population (Orfordness and Havergate). (Considering all colonies within MMFR+1SD (Standard Deviation) to have potential connectivity to the array areas would bring in additional breeding sites in North Norfolk, although these more distant colonies would be unlikely to significantly affect the apportioning estimates due to the assumption of an inverse relationship between the number of birds from a colony foraging within a given area and distance; SNH 2018).

1263. Birds recorded in the array areas during the breeding season may also include sub-adult birds and sabbatical adults of breeding age, as well as breeding adults. The mean percentage of lesser black-backed gulls that were identified as adults during monthly baseline surveys in the breeding season (March to August) was 83% from the sample of records for which the age class could be determined (PEIR Appendix 13.2 (Volume III); on average it was not possible to age 49% of lesser black-backed gulls recorded during breeding season months). Thus these observations confirm that a proportion of birds recorded during the breeding season were sub-adults. It is also likely that a relatively high proportion of the birds recorded in adult plumage are non-breeders or ‘sabbaticals’ (e.g. Royal HaskoningDHV, 2022b) have recommended assuming 35% of lesser black-backed gulls recorded in adult plumage on OWF sites during the breeding season are ‘sabbaticals’). This is not accounted for in the current assessment, making it highly precautionary in this regard.

7.3.3.1.2.2 Non-breeding season

1264. Outside the breeding season, lesser black-backed gulls from the Alde-Ore SPA colonies migrate away from the breeding colony, with some birds remaining in the UK during the winter and others travelling to continental Europe and north Africa (Thaxter et al. 2019). The relevant reference population is considered to be the UK North Sea and Channel Biologically Defined Minimum Population Scales (BDMPS). This consists of 209,007 individuals during autumn migration (September to October), 39,314 individuals during winter (November to February) and 197,483 individuals during spring migration (March) (Furness, 2015). Note for the project alone assessment of collision risk the non-breeding season is divided into migration and winter periods, but for the in-combination assessment data is not consistently available for other OWFs for these subdivisions, so a single non-breeding season estimate is presented.

1265. For the project alone assessment, estimates of the proportion of lesser black-backed gulls present in the array areas which originate from the Alde-Ore Estuary SPA during the non-breeding season (and therefore the proportion of predicted mortalities from the SPA population) are based on the SPA population of breeding adults as a proportion of the relevant seasonal BDMPS (UK North Sea and Channel). During autumn migration, winter, and spring migration, 0.61%, 1.63%, and 0.65% respectively of impacts are considered to affect breeding adults from the SPA population (based on data in the appendices to Furness, 2015). For the in-combination assessment, the non-breeding season proportion of adults is based on a weighted average of the seasonal proportions.

Table 7.9 Counts of breeding lesser black-backed gulls in Suffolk and south Norfolk 2012 and apportioning for North Falls (Piotrowski 2013)

	No. Pairs	Urban	Natural[1]	Distance to North Falls (km)[2]	Proportion of sea within MMFR[3]	Colony size weighting[4]	Distance weighting[4]	Proportion of sea weighting[4]	Combined weighting[4]	% of birds at North Falls from colony[4]
Breydon Water	1	1		95	0.70	0.00	165.96	0.05	0.00	0 %
Great Yarmouth	743	743		94	0.71	0.16	165.96	0.04	1.20	4 %
Southtown/Gorleston	467	467		91	0.71	0.10	193.34	0.04	0.82	3 %
Lowestoft	627	627		79	0.71	0.13	283.79	0.05	1.44	5 %
Beccles	34	34		79	0.66	0.01	253.68	0.05	0.08	0 %
Ellough	12	12		78	0.66	0.00	263.16	0.05	0.03	0 %
Pakefield (south Lowestoft)	31	31		77	0.70	0.01	295.03	0.05	0.08	0 %
Minsmere[3]	1		1	56	0.64	0.00	704.66	0.05	0.00	0 %
Aldeburgh	1	1		48	0.62	0.00	1135.17	0.05	0.01	0 %
Orfordness[4]	640		640	42	0.59	0.14	1227.80	0.05	6.19	21 %
Havergate Island[4]	1171		1171	43	0.59	0.25	1227.80	0.05	11.07	38 %
Port of Felixstowe	675	675		45	0.52	0.14	560.54	0.06	6.60	23 %
East Ipswich	93	93		55	0.50	0.02	435.02	0.06	0.63	2 %
Ipswich docks & town centre	133	133		60	0.48	0.03	319.61	0.07	0.80	3 %
West Ipswich	36	36		62	0.47	0.01	306.95	0.07	0.20	1 %
Great Blakenham	1	1		67	0.47	0.00	263.16	0.07	0.00	0 %
Stowmarket	6	6		78	0.44	0.00	187.35	0.07	0.02	0 %
Mendlesham	22	22		78	0.48	0.00	213.16	0.07	0.08	0 %
Totals	4694	2882	1812	1227	10.66		7182.73		29.25	

1. Typical natural-nesting sites include cliffs, moorland, agricultural land, freshwater margins and islands (Burnell 2021).

2. Approximate distance between the central point of North Falls and the approximate centre of the colony based on descriptions in Piotrowski (2013).

3. The proportion of sea within a circle from each colony with radius equivalent to the foraging range (in this case MMFR, 127km) = (area of sea within 127km of colony / (total area (land and sea) within 127km of colony).

	No. Pairs	Urban	Natural[1]	Distance to North Falls (km)[2]	Proportion of sea within MMFR[3]	Colony size weighting[4]	Distance weighting[4]	Proportion of sea weighting[4]	Combined weighting[4]	% of birds at North Falls from colony[4]
4. The likely proportion of birds from each breeding site at North Falls during the breeding season estimated based on SNH (2018) apportioning guidance. Colony weighting = site population (individuals) / sum of site populations (individuals); distance weighting = (sum of site distances)^2 / (site distance)^2; proportion of sea weighting = (1/colony sea proportion / (sum of (1/colony sea proportions)); combined weighting = colony weight x distance weight x proportion of sea weight; % of birds from site a North Falls = combined site weighting / sum of combined site weight x 100.										
3. The numbers of nesting lesser black-backed gulls at this site are controlled (Piotrowski 2013) to reduce predation on other bird species of conservation concern.										
4. Counts for breeding colonies within the Alde-Ore SPA; the count for Orfordness is the same as the 2012 count in the SMP (2022) database, for Havergate the database records 1267 breeding pairs in 2012.										

7.3.3.1.3 Project alone assessment

1266. The assessment assumes that during the breeding season, 83% of predicted lesser black-backed gull collisions involve breeding adults, and of these, 59% are associated with the Alde-Ore Estuary SPA population.

1267. During the non-breeding season months, the proportion of collisions in the array areas affecting the SPA population is estimated as in paragraph 1265 above.

1268. Annual predicted mortality from collisions in the array areas as a percentage increase in the mortality rate of the SPA population is given in Table 7.10, for the three WTG scenarios and nocturnal activity factors of 0.25 and 0.5. For scenarios 1a and 1b the mean predicted collisions apportioned to the SPA are equivalent to >1% increase in the mortality rate of the SPA population of breeding adults. For scenario 2 the mean predicted collisions apportioned to the SPA represents less than a 1% increase in the SPA population mortality. The upper 95% confidence limits of collision risk estimates for all WTG options represent increases of >1% in population mortality rates, however these collision predictions are extremely unlikely to occur.

1269. The potential impacts from the predicted project alone mortality can be investigated in more detail using a population model for lesser black-backed gull at the Alde-Ore Estuary SPA (MacArthur Green 2019a). The model used a matrix formulation and included environmental and demographic stochasticity. Density independent and density dependent versions were developed, with the former incorporating no feedback between population size and demographic rates (such that a population can either increase to infinity (which is biologically implausible) or decrease to extinction), and the latter incorporating feedback so that reproductive rate varies inversely with population size. This latter approach means that the model incorporates a mechanism for population regulation, which is likely to be more realistic (e.g. reproductive rates may be expected to decline as population size increases if an expanding population resulted in competition for food resources and/or suitable nesting sites). Based upon these population models, PVA was undertaken by comparing the population projections under baseline conditions (i.e. without any OWF effects) and under conditions with the additional mortality predicted from the OWF effects incorporated (MacArthur Green 2019a). A 'matched runs' approach was taken as recommended by Natural England. Demographic rates were taken from Horswill and Robinson (2015). The initial population size of 2,000 pairs was based on the number of breeding pairs recorded between 2010-2016 in the SMP database.

1270. The PVAs incorporated a range of additional mortality values, increasing in increments of 5 adults from zero to an upper value of 100 adults (which is in excess of the highest project alone and in-combination value under consideration). Additionally, for each incremental level of adult mortality, mortality was applied to the subadult age classes in proportion to the stable age distribution estimated by the population model. Thus, outputs for a mortality rate of 100 adults actually represent a total mortality (for all age classes) which will be approximately double this, since adults represented 58% to 60% of the population (as estimated respectively from stable age distributions for the density independent and density dependant models).

1271. Models assumed that the lesser black-backed gull breeding population at the Alde-Ore Estuary is closed. In reality, this will not be the case as there will be immigration and emigration resulting in exchange of birds between colonies (Ross-Smith et al. 2014b). Models were run for a period of 30 years.

1272. It was noted that the demographic data for lesser black-backed gull used in the model were scored as low quality by Horswill and Robinson (2015). Nevertheless, these are the best available data and the use of counterfactuals for population model outputs is relatively insensitive to mis-specification of demographic rates (MacArthur Green (2019). Thus, the models for lesser black-backed gull at the Alde-Ore Estuary were considered to be robust. Models of the population without impacts from OWF mortality predicted a population growth rate in excess of 10% suggesting that, using the more precautionary density independent model, additional adult mortality of up to 120 individuals, corresponding to a 3% reduction in growth rate, would be unlikely to trigger a population decline. These projections do not however reflect the historical trends of the SPA breeding colonies at the Alde-Ore Estuary (Figure 7.3) where, as described above, large scale declines in the early 2000s are thought to have involved emigration by breeding adults due to disturbance from predation; and current trends of the SPA population are unclear.

1273. Model PVA outputs are presented in Table 7.11 for adult mortality levels which correspond most closely to the project alone (and in combination) mortality predictions for lesser black-backed gull in the array areas. The outputs are presented as the counterfactuals (or ratios) of population size (CPS) and annual population growth rate (CPGR) for models incorporating in combination mortality from OWFs (impacted populations) in relation to models without OWF mortality (unimpacted populations). For each mortality level, the table shows the predicted changes in median population growth rate calculated between year five and year 30, and the counterfactual of population size at year 30 (with upper and lower 95% confidence intervals).

1274. For North Falls alone, the mean predicted collision mortality apportioned to the SPA ranges from approximately 4-6 breeding adults (Table 7.10). Under the density independent model, for a predicted additional mortality of 5 breeding adults, the median predicted reduction in the population growth rate of lesser black-backed gulls at the Alde-Ore estuary after 30 years was 0.1% (0.999) compared with an unimpacted population, and the predicted reduction in population size was 3.5% (0.965). For the density dependent model, there was no predicted median reduction in growth rate (1.000), and a 1.1% (0.989) predicted reduction in population size after 30 years (Table 7.11).

1275. Thus the population models predict an extremely small or no reduction in the population growth rate, and a very small reduction in population size, over 30 years, with additional mortality of 5 breeding adults. Due to the intrinsic structure of the population modelling approach, increases in mortality rates will always have some effect on population size and growth rate, such that the counterfactuals of impacted and unimpacted populations will never be greater than 1 and will almost always be less, thus always suggesting a negative effect. What is undefined is the level at which such negative effects could cause detectable adverse effects on a population.

1276. In this case the predicted reductions in population growth rate (max 0.1%) and size (max 3.5%) after 30 years from project-alone mortality are considered to be so small that they would have no detectable effect on the lesser black-backed gull breeding population of the Alde-Ore Estuary. Further that project alone collision risk mortality would not compromise conservation measures to support the achievement of the restore target for the SPA population (Section 7.3.3.1.1).

1277. It is concluded that predicted collisions at North Falls alone would not have an adverse effect on the Alde-Ore Estuary SPA breeding population of lesser black-backed gull.

1278. Natural England's (2022c) interim advice on CRM parameters recommends that the avoidance rate for lesser black-backed gull is reduced from 99.5% (99.4-99.6) (PEIR Chapter 13 Volume I, Table 13.34) to 99.4 (±0.04). Although this guidance was received after CRM was completed for the North Falls PEIR, it's application would increase the predicted collision risk for this species at North Falls by about 20%. This scale of increase could affect the conclusion above. Post-PEIR, the North Falls assessment will be updated to reflect the new guidance on CRM.

1279. However, there may also be sources of precaution in the collision risk estimates presented. The nocturnal activity factors used for lesser black-backed gull in collision risk modelling may be overestimated. The range recommended by Natural England (2022) is between 0.25-0.5, indicating that flight activity is 25-50% of that during the daytime. A review of seabird nocturnal activity carried out for East Anglia THREE (MacArthur Green 2015a&b) cites a study of migration behaviour (Klaassen et al. 2012) where an average of 48% of daylight and 12% of night was spent in flight, equivalent to 25% nocturnal activity. A study of GPS-tracked lesser black-backed gulls breeding at Orfordness (Ross-Smith et al. 2016) found that they spent relatively little time flying at night (0.3% of their total time), and also that birds flew at lower altitudes at night, especially over the sea. If this is representative of the behaviour of this species during the breeding season it suggests that the risk of collisions with OWFs at night may actually very small and may even be over-estimated by the lowest nocturnal activity factor of 0.25.

Table 7.10 Seasonal and annual collisions for lesser black-backed gull at North Falls apportioned to Alde-Ore Estuary SPA and increase in SPA population mortality rates (grey shading indicates worst case scenario)

WTG scenario	Nocturnal activity factor	Statistic	Apportioning[1]	Predicted collisions (sCRM)					Annual collisions as % increase in SPA population mortality rate[2]
				Aut-mig	Winter	Spr-mig	Breed-full	Annual	
1a	0.25	Mean	All	1.36	2.17	0.90	9.46	13.9	-
			Apportioned to SPA	0.01	0.04	0.01	4.61	4.66	1.1
		LCI	All	0.13	0.15	0.05	1.65	1.99	-
			Apportioned to SPA	0.00	0.00	0.00	0.80	0.81	0.2
		UCI	All	3.59	5.89	2.49	22.92	34.89	-
			Apportioned to SPA	0.02	0.10	0.02	11.16	11.29	2.6
	0.5	Mean	All	1.51	2.49	1.04	9.96	14.99	-
			Apportioned to SPA	0.01	0.04	0.01	4.85	4.91	1.2
		LCI	All	0.12	0.24	0.06	1.66	2.08	-
			Apportioned to SPA	0.00	0.00	0.00	0.81	0.81	0.2
		UCI	All	3.88	6.73	2.97	23.10	36.68	-
			Apportioned to SPA	0.02	0.11	0.02	11.25	11.40	2.7
1b	0.25	Mean	All	1.54	2.47	1.03	10.64	15.69	-
			Apportioned to SPA	0.01	0.04	0.01	5.18	5.24	1.2
		LCI	All	0.15	0.16	0.05	1.58	1.94	-
			Apportioned to SPA	0.00	0.00	0.00	0.77	0.77	0.2
		UCI	All	4.16	6.44	2.86	25.85	39.31	-
			Apportioned to SPA	0.03	0.10	0.02	12.59	12.73	3.0
	0.5	Mean	All	1.97	3.26	1.27	12.32	18.81	-

WTG scenario	Nocturnal activity factor	Statistic	Apportioning[1]	Predicted collisions (sCRM)					Annual collisions as % increase in SPA population mortality rate[2]
				Aut-mig	Winter	Spr-mig	Breed-full	Annual	
			Apportioned to SPA	0.01	0.05	0.01	6.00	6.07	1.4
		LCI	All	0.14	0.28	0.06	2.00	2.48	-
			Apportioned to SPA	0.00	0.00	0.00	0.97	0.98	0.2
		UCI	All	5.13	8.21	3.51	28.62	45.47	-
			Apportioned to SPA	0.03	0.13	0.02	13.93	14.12	3.3
2	0.25	Mean	All	1.06	1.68	0.69	7.28	10.7	-
			Apportioned to SPA	0.01	0.03	0.00	3.54	3.58	0.8
		LCI	All	0.10	0.16	0.03	1.08	1.36	-
			Apportioned to SPA	0.00	0.00	0.00	0.53	0.53	0.1
		UCI	All	2.70	4.43	1.92	17.45	26.5	-
			Apportioned to SPA	0.02	0.07	0.01	8.50	8.60	2.0
	0.5	Mean	All	1.22	2.02	0.81	7.89	11.93	-
			Apportioned to SPA	0.01	0.03	0.01	3.84	3.89	0.9
		v	All	0.10	0.17	0.05	1.34	1.66	-
			Apportioned to SPA	0.00	0.00	0.00	0.65	0.66	0.2
		uci	All	3.17	5.34	2.20	18.70	29.41	-
			Apportioned to SPA	0.02	0.09	0.01	9.10	9.23	2.2

1. SPA apportioning of predicted collisions at North Falls: autumn migration 0.61%, winter 1.63%, spring migration 0.65%, breeding 59%
2. Based on annual adult mortality rate of 0.115 (PEIR Chapter 13 Volume I, Table 13.13)

Table 7.11 Outputs from a population model of lesser black-backed gull at Alde-Ore Estuary SPA (MacArthur Green 2019): counterfactuals of population growth rate and size for models including and excluding predicted mortality from in combination collisions at OWFs

Model	Adult mortality	Statistic	Counterfactual of population size						Counterfactual of growth rate between year 5 and year 30
			Year 5	Year 10	Year 15	Year 20	Year 25	Year 30	
Density independent	5	Lower 95%	0.976	0.955	0.938	0.920	0.909	0.892	0.996
		Median	0.994	0.988	0.982	0.976	0.970	0.965	0.999
		Upper 95%	1.013	1.021	1.025	1.030	1.034	1.039	1.002
	10	Lower 95%	0.968	0.943	0.922	0.901	0.875	0.859	0.995
		Median	0.990	0.977	0.964	0.952	0.940	0.927	0.997
		Upper 95%	1.012	1.012	1.010	1.004	1.006	1.000	1.001
	45	Lower 95%	0.935	0.870	0.811	0.759	0.710	0.666	0.986
		Median	0.956	0.904	0.854	0.808	0.762	0.720	0.989
		Upper 95%	0.977	0.937	0.896	0.861	0.818	0.786	0.992
	50	Lower 95%	0.930	0.858	0.798	0.741	0.688	0.636	0.984
		Median	0.951	0.893	0.839	0.788	0.738	0.695	0.987
		Upper 95%	0.972	0.927	0.882	0.834	0.795	0.757	0.991
Density dependent	5	Lower 95%	0.980	0.971	0.969	0.968	0.968	0.965	0.999
		Median	0.995	0.992	0.990	0.990	0.989	0.989	1.000
		Upper 95%	1.011	1.015	1.014	1.011	1.011	1.011	1.001
	10	Lower 95%	0.976	0.966	0.961	0.959	0.958	0.956	0.998
		Median	0.992	0.987	0.983	0.981	0.979	0.978	0.999
		Upper 95%	1.007	1.007	1.005	1.002	1.001	1.001	1.001

Model	Adult mortality	Statistic	Counterfactual of population size						Counterfactual of growth rate between year 5 and year 30
			Year 5	Year 10	Year 15	Year 20	Year 25	Year 30	
	45	Lower 95%	0.949	0.917	0.900	0.889	0.883	0.878	0.996
		Median	0.965	0.938	0.922	0.913	0.907	0.904	0.997
		Upper 95%	0.979	0.959	0.944	0.935	0.930	0.927	0.999
	50	Lower 95%	0.944	0.909	0.890	0.880	0.873	0.868	0.996
		Median	0.961	0.931	0.914	0.903	0.896	0.892	0.997
		Upper 95%	0.977	0.952	0.936	0.925	0.920	0.919	0.998

7.3.3.1.4 In combination assessment

1280. The in-combination assessment considers the combined predicted collision risk to lesser black-backed gulls at the Alde-Ore Estuary SPA from OWFs within foraging range during the breeding season, and within the UK North Sea and Channel BDMPS (Furness 2015) during the non-breeding season. In each season the predicted collision risk from OWFs within the area of search is apportioned to the SPA. In combination seasonal and annual totals are set out in Table 7.12.

1281. During the breeding season, the predicted collision risk for North Falls is apportioned to the Alde-Ore SPA as described in paragraph 1262 above. The worst case estimate of collision risk is used (scenario 1b, nocturnal activity factor 0.5, Table 7.10). Other OWFs within breeding season foraging range could be selected based on those within MMFR (127 km) or MMFR +1SD (236 km) (Woodward et al. 2019) of the Alde-Ore SPA (Table 7.12 indicates which sites fall within each range). The maximum at sea foraging range recorded from a three-year study of lesser black-backed gulls nesting at the SPA was 159 km (Thaxter et al. 2015), which suggests that the MMFR would be more appropriate.

1282. For PEIR, it was considered appropriate to use the breeding season apportioning for OWFs and the Alde-Ore Estuary SPA as set out in MacArthur Green and Royal HaskoningDHV (2020, 2021) for East Anglia ONE North and TWO. This analysis used a breeding season foraging range of 181 km based on the maximum foraging range from Thaxter et al. (2012) (the previous industry standard reference for seabird foraging ranges which was updated by Woodward et al. 2019). Breeding season apportioning for East Anglia ONE North and TWO was based on SNH (2018) methodology and, in addition to the Alde-Ore SPA, the lesser black-backed gull breeding colonies considered included the larger colonies listed in Table 7.9 above plus one additional large colony at Outer Trial Bank in the Wash SPA.

1283. Outside the breeding season, when lesser black-backed gulls leave their breeding colonies, apportioning of non-breeding season collisions to OWFs was based on the Alde-Ore SPA population as a proportion of the UK North Sea and Channel BDMPS. As detailed above, the non-breeding season for lesser black-backed gull is divided into spring and autumn migration and winter periods (Furness 2015). However, for many OWFs included in the in-combination assessment there is not enough information to calculate separate estimates for these periods, and only a single non-breeding season estimate is available. During autumn migration, winter, and spring migration, 0.61%, 1.63%, and 0.65% of impacts, respectively, are considered to affect breeding adult birds from the SPA (based on data in the appendices to Furness, 2015). A weighted average, based on the months allocated to each season (assuming a full UK breeding season, Furness 2015), is 1.2% for the non-breeding season.

1284. The annual predicted in combination mortality for the lesser black-backed gull breeding population at the Alde-Ore SPA is 47 birds (Table 7.12). Four OWFs have recently been consented subject to compensation for predicted collision mortality at Alde-Ore Estuary SPA, East Anglia ONE North and TWO, Norfolk Vanguard and Norfolk Boreas. For these sites compensation measures are due to be in place to offset the predicted collision mortality for SPA birds. Thus the contribution of these OWFs can be deducted from the in-combination total, which leaves 44 birds. Of these, North Falls contributes 6 birds, 14% of the total.

1285. Assuming the predicted annual total of 44 deaths from OWF collisions involves breeding adults from the SPA population, this represents an increase of 10 % in the population mortality rate.

1286. For North Falls, lesser black-backed gulls recorded within the array areas during the breeding season included adults and sub-adult birds, and a correction was applied to the breeding season collisions total to account for this. It is understood that similar corrections to the predicted breeding season totals have not been applied to most or all OWFs included in the in-combination assessment where there is breeding season connectivity. This indicates that the numbers of adults predicted to die will be an overestimate to some degree. During the non-breeding season the apportioning is based on the estimated proportion of adult birds from the Alde-Ore estuary within the seasonal BDMPSs, based on Furness (2015), so is focused on the numbers of breeding adults.

1287. As for the project alone assessment, the predicted in combination mortality from collisions is compared to PVA outputs in Table 7.11 for adult mortality levels which correspond most closely.

1288. Under the density independent model, at an in-combination mortality of 45 breeding adults, the median predicted reduction in the population growth rate of lesser black-backed gulls at the Alde-Ore estuary after 30 years was 1.1% (0.989) compared with an unimpacted population, and the predicted reduction in population size was 28% (0.720). For the density dependent model, the equivalent predicted median reduction in growth rate was 0.3% (0.997), and for population size after 30 years 9.6% (0.904) (Table 7.11).

1289. Given the magnitude of the counterfactuals, predicting that the impacted SPA population would be approximately 10-28% smaller after 30 years than the baseline; and the fact that the SPA population is subject to a restore target, it is considered that the potential for adverse effects on the SPA population of lesser black-backed gull cannot be excluded.

1290. As noted above, Natural England’s (2022c) interim advice on CRM parameters recommends that the avoidance rate for lesser black-backed gull is reduced from 99.5% (99.4-99.6) to 99.4 (±0.04). Although this guidance was received after CRM was completed for the North Falls PEIR, it’s application would increase the predicted collision risk for this species for North Falls and other OWFs included in the in-combination assessment by about 20%.

1291. Set against this, there are substantial levels of precaution built into the in-combination mortality predictions, notably in two areas. Firstly, the use of collision risk based on consented worst-case rather than as-built OWF parameters may lead to the overestimation of collision rates by up to 40% (MacArthur Green, 2017; The Crown Estate and Womble Bond Dickinson, 2021). However, whilst the as-built designs represent the most realistic scenario in terms of the existing collision risk, these are not considered by some stakeholders to be legally secured (at least for projects in English waters), so there is a theoretical (albeit highly unlikely) possibility of further WTG construction on such project sites (The Crown Estate and Womble Bond

Dickinson 2021). Secondly, the assumed maximum nocturnal activity of 50% may be an overestimate. Also as discussed above (paragraph 1279) available information for lesser black-backed gull suggests that nocturnal activity values of 25% are most realistic (as opposed to 50%). It is estimated that the use of the evidence-based nocturnal activity factor would reduce predicted collision rates by approximately 20%, though this varies by OWF location and season/day length (MacArthur Green 2015b). Furthermore, consideration has been given to the likely presences of sabbatical adults (birds which do not breed in a given year) (paragraph 1263 above).

1292. As noted previously, consent applications for the most recent OWFs in the southern UK North Sea have been granted subject to compensation measures for lesser black-backed gull at the Alde-Ore Estuary. These consents are for Norfolk Vanguard, Norfolk Boreas, East Anglia ONE North and East Anglia TWO. In each case the Secretary of State has concluded that an AEoI of the Alde-Ore Estuary SPA from in combination collision mortality to lesser black-backed gull cannot be excluded (BEIS 2021, 2022a, b, c).

1293. Thus, the RIAA presented in the PEIR for North Falls is accompanied by a without prejudice report on potential compensation measures for lesser black-backed gull at the Alde-Ore Estuary.

Table 7.12 In combination collision risk for lesser black-backed gull at the Alde-Ore Estuary (AOE) SPA

Tier	OWF	Overlap with foraging range from AOE[1]		Predicted number of collisions (in total and apportioned to SPA[2])						Consented subject to compensation for lesser black-backed gull at AOE
		Mean max+ 1SD (236km)	Mean max (127km)	Breeding		Non-breeding		Annual		
				Total	SPA	Total	SPA	Total	SPA	
1	Beatrice Demonstrator	No	No	0	0	0	0	0	0	
1	Beatrice	No	No	0	0	0	0	0	0	
1	Blyth Demonstration	No	No	0	0	0	0	0	0	
1	Dudgeon	Yes	Yes	7.7	1.2	30.6	0.4	38.3	1.5	
1	East Anglia ONE	Yes	Yes	5.9	2.2	33.8	0.4	39.7	2.6	
1	EOWDC (Aberdeen)	No	No	0	0	0	0	0	0	
1	GWF	Yes	Yes	27.8	18.1	111	1.3	138.8	19.4	
1	GGOW	Yes	Yes	12.4	8.1	49.6	0.6	62	8.7	
1	Gunfleet Sands	Yes	Yes	1	0.4	0	0	1	0.4	
1	Hornsea Project One	Yes	No	4.4	0	17.4	0.2	21.8	0.2	
1	Humber Gateway	Yes	No	0.3	0	1.1	0	1.4	0	
1	Hywind	No	No	0	0	0	0	0	0	
1	Kentish Flats and Extension	Yes	Yes	0.3	0.1	1.3	0	1.6	0.1	
1	Kincardine	No	No	0	0	0	0	0	0	
1	Lincs	Yes	No	1.7	0	6.8	0.1	8.5	0.1	
1	London Array	Yes	Yes	0	0	0	0	0	0	
1	Lynn and Inner Dowsing	Yes	No	0	0	0	0	0	0	
1	Methil	No	No	0.5	0	0	0	0.5	0	
1	Moray East	No	No	0	0	0	0	0	0	

Tier	OWF	Overlap with foraging range from AOE[1]		Predicted number of collisions (in total and apportioned to SPA[2])						Consented subject to compensation for lesser black-backed gull at AOE
		Mean max+ 1SD (236km)	Mean max (127km)	Breeding		Non-breeding		Annual		
				Total	SPA	Total	SPA	Total	SPA	
1	Race Bank	Yes	No	43.2	0	10.8	0.1	54	0.1	
1	Rampion	Yes	No	1.6	0	6.3	0.1	7.9	0.1	
1	Scroby Sands	Yes	Yes	0	0	0	0	0	0	
1	Sheringham Shoal	Yes	Yes	1.7	0.3	6.6	0.1	8.3	0.3	
1	Teeside	No	No	0	0	0	0	0	0	
1	Thanet	Yes	Yes	3.2	1.4	12.8	0.2	16	1.5	
1	Triton Knoll	Yes	No	7.4	0	29.6	0.4	37	0.4	
1	Westermost Rough	Yes	No	0.1	0	0.3	0	0.4	0	
2	Dogger Bank A and B	No	No	2.6	0	10.4	0.1	13	0.1	
2	Dogger Bank C and Sofia	No	No	2.4	0.0	9.6	0.1	12	0.1	
2	Forth (Seagreen) Alpha and Bravo	No	No	2.1	0.0	8.4	0.1	10.5	0.1	
2	Hornsea Project Two	Yes	No	2	0.0	2	0	4	0	
2	Moray West	No	No	0	0.0	0	0	0	0	
2	Neart na Gaoithe	No	No	0.3	0.0	1.2	0	1.5	0	
3	East Anglia ONE North	Yes	Yes	0.9	0.2	0.6	0	1.5	0.2	Yes
3	East Anglia THREE	Yes	Yes	1.8	0.4	8.2	0.1	10	0.5	
3	East Anglia TWO	Yes	Yes	4.2	1.6	0.5	0	4.7	1.6	Yes
3	Hornsea Project Three	Yes	No	8	0.0	1	0	9	0	
3	Inch Cape	No	No	0	0.0	0	0	0	0	
3	Norfolk Boreas	Yes	Yes	6.2	1.3	8.1	0.1	14.3	1.4	Yes

Tier	OWF	Overlap with foraging range from AOE[1]		Predicted number of collisions (in total and apportioned to SPA[2])						Consented subject to compensation for lesser black-backed gull at AOE
		Mean max+ 1SD (236km)	Mean max (127km)	Breeding		Non-breeding		Annual		
				Total	SPA	Total	SPA	Total	SPA	
3	Norfolk Vanguard	Yes	Yes	8.4	1.4	3.6	0	12	1.5	Yes
4	Hornsea Project Four	Yes	No	0.8	0.0	0.0	0	0.8	0	
4	Dudgeon and Sheringham Shoal Extns	Yes	Yes	1.6	0.0	0.3	0	1.9	0	
5	North Falls	Yes	Yes	12.3	6.0	6.5	0.1	18.8	6.1	
5	Rampion 2	Yes	No	0.6	0.0	1.2	0.0	1.8	0	
TOTALS				**173**	**43**	**380**	**5**	**553**	**47**	
TOTAL excluding sites with compensation measures									**44**	

1. Foraging ranges from Woodward et al. 2019.

2. Breeding season apportioning of the AOE population for North Falls is as described in paragraph 1262 above, and for other OWFs follows the approach described in MacArthur Green and Royal HaskoningDHV (2020) and the total numbers of collisions for each OWF in MacArthur Green and Royal HaskoningDHV (2021). During the non-breeding season apportioning is based on the Alde-Ore Estuary SPA population as a proportion of the UK North Sea and Channel BDMPS (Paragraph 1283).

7.4 Flamborough and Filey Coast SPA

7.4.1 SPA overview

1294. The Flamborough and Filey Coast SPA was designated in 2018. It is a geographical extension to the former Flamborough Head and Bempton Cliffs SPA, which was designated in 1993, to include Filey Cliffs, an additional section of coastline to the north (thus the Flamborough and Filey Coast SPA now subsumes this previous designation).

1295. The SPA is located on the Yorkshire coast between Bridlington and Scarborough, and is composed of two sections. The northern section runs from Cunstone Nab to Filey Brigg. The southern section runs from Speeton to South Landing, and includes Bempton Cliffs and Flamborough Head. The seaward boundary extends 2km offshore and applies to both sections of the SPA.

1296. The predominantly chalk cliffs of Flamborough Head rise to 135m and have been eroded into a series of bays, arches, pinnacles and gullies, as well as sheer cliffs. The cliffs from Filey Brigg to Cunstone Nab are formed from various sedimentary rocks including shales and sandstones. The adjacent sea out to 2km is characterised by reefs supporting kelp forest communities in the shallow subtidal, and faunal turf communities in deeper water. The southern side of Filey Brigg shelves off gently from the rocks to the sandy bottom of Filey Bay.

1297. The SPA cliffs support internationally important breeding colonies of seabirds. The marine extension is used by seabirds from these colonies for behaviours such as loafing, preening and courtship).

7.4.2 Conservation Objectives

1298. The site's conservation objectives are to:

- Ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:
- The extent and distribution of the habitats of the qualifying features;
- The structure and function of the habitats of the qualifying features;
- The supporting processes on which the habitats of the qualifying features rely;
- The populations of each of the qualifying features; and
- The distribution of qualifying features within the site.

7.4.3 Shadow Appropriate Assessment

1299. All qualifying species of this SPA have been screened into the Appropriate Assessment. These are breeding gannet, breeding kittiwake, breeding guillemot, and breeding razorbill. The breeding seabird assemblage is also a qualifying feature.

1300. At PEIR, an appropriate assessment is presented for kittiwake, guillemot and razorbill, as Natural England has advised that North Falls is considered to have the potential to contribute to an in combination AEoI, along with other UK OWFs in the North Sea, on the SPA populations of these species. The RIAA which accompanies the DCO submission will include appropriate assessments for all qualifying features of the Flamborough and Filey Coast SPA that have been screened in.

7.4.3.1 Kittiwake

7.4.3.1.1 Status

1301. The SPA citation population of 44,520 Apparently Occupied Nests (AONs) is based on the kittiwake counts undertaken in 2008 (Bempton and Flamborough Head original SPA) and between 2009-2011 (including the SPA Filey coast extension) and assumes that one AON represents one breeding pair (so equating to 89,040 breeding adult birds). Most of the kittiwakes (approximately 89%) nest in the southern Bempton to Flamborough Head part of the SPA; the rest breed on the cliffs in the northern part of the SPA (i.e., at Filey).

1302. Since the SPA citation counts (2008-2011) there was an apparent modest increase in numbers, from 44,520 pairs to 51,001 pairs in 2016 (Babcock et al., 2016) and 51,535 pairs (2017 count of AON, SMP database, Aitken et al. 2017. The most recent whole-colony count in 2022 found 44,574 pairs, a decline since 2017; during the 2022 count period some deaths from Highly Pathogenic Avian Influenza (HPAI) were considered likely for some species (although kittiwake is not mentioned), and after the count was completed larger numbers of dead adult and juvenile birds, including kittiwakes, were reported on local beaches and on and below the cliffs (Clarkson et al. 2022).

1303. There is uncertainty over the long-term trend in the size of this SPA population, with an apparent peak count in 1987 of 83,700 pairs at Flamborough and Bempton Cliffs (Natural England 2020) and over 85,000 pairs with Filey cliffs included (Clarkson et al. 2022). This suggests that the population underwent a major decline between the late 1980s and late 1990s. However, there is uncertainty over the veracity of the 1987 count, with a lack of supporting detail being available on survey methods. More recent whole-colony counts include observations made from land and sea (from small boats able to access close to shore). An enquiry into the RSPB Bempton Cliffs annual reports in the 1970s and 1980s indicated that most counts made were land-based with estimates calculated for (at least some) sections of cliff that were not visible from land. As large areas of the colony are not visible from land it is considered that these whole colony estimates should be treated with caution (Carkson et al. 2022). Associated monitoring of breeding productivity during the late 1980s and 1990s predicts an increasing, not declining, population trend during this period (Coulson 2011, 2017). As such, it is unclear whether this SPA population has been subject to an increase from the 1950s to late 1980s, followed by a marked long-term decline, or a gradual increase since the 1950s (with reference to trends reported in Clarkson et al. 2022). Despite this uncertainty the SPA conservation objectives are based on the premise that the population has undergone a marked long-term decline, with the Supplementary Advice on Conservation Objectives (SACOs) for the '*breeding population: abundance*' attribute having the target of restoring the size of the breeding population at a level which is above 83,700 breeding pairs, whilst avoiding deterioration from its current level.

1304. There is no specified status on the Natural England website regarding the condition of the qualifying features of the Flamborough and Filey Coast SPA, although (as stated above) the SACOs have a target to restore the size of the population of the kittiwake feature.

7.4.3.1.2 Connectivity and seasonal apportionment of potential effects

Breeding season

1305. The seabird colonies within the Flamborough and Filey Coast SPA are the only SPA colonies where kittiwake is a qualifying interest that are close enough to North Falls to be candidates for breeding season connectivity.

1306. The MMFR of breeding kittiwakes based on tracking data from 37 colonies around the UK is 156.1km (Woodward et al., 2019), well short of the distance between this SPA and the North Falls array areas. However, there is substantial between-colony variation, with the birds at some colonies showing a tendency to travel further than those at others. In the absence of site-specific data, it is recommended best practice (Natural England, 2022b) to determine the potential for connectivity between an OWF site and colonies on the generic MMFR+1SD distance, equating to 300.6km for kittiwake. This would mean that parts (but not all) of the North Falls array areas are within range of kittiwakes breeding at Flamborough and Filey Coast SPA colonies. On this basis it would be concluded that there is potential for breeding season connectivity between the Flamborough and Filey Coast SPA colonies and North Falls array areas.

1307. However, there are also two smaller non-SPA colonies, both of which are considerably closer to the array areas, that are also candidates. The question of what proportion (if any) of the kittiwakes using the array areas in the breeding season are likely to be from Flamborough and Filey Coast SPA, and what proportion are from other sites is examined below.

1308. The North Falls array areas lie between 269km and 318km from the closest kittiwake colony within the Flamborough and Filey Coast SPA, which is the colony at Flamborough Head. The kittiwake colonies in the northern part of the SPA (i.e. the Filey part) are approximately 18km further away.

1309. There is uncertainty as to the colony origins and status of the kittiwakes in adult plumage recorded during the breeding season in the North Falls baseline surveys. There are three possibilities, all of which are likely to be true to some extent.

1310. First, part of the North Falls site lies within the maximum recorded foraging distance of kittiwakes breeding at Flamborough Head, with much of the SPA itself within the MMFR plus 1 standard deviation breeding season foraging range of kittiwake (Woodward *et al.* 2019). Therefore, one possibility is that some of the birds are actively breeding birds from large colonies within the Flamborough and Filey Coast SPA, which represent the only large colonies potentially within foraging range. However, the distance between the North Falls site and these Flamborough and Filey Coast SPA colonies is well beyond the typical distance travelled by breeding kittiwakes to forage.

1311. RSPB's Future of the Atlantic Marine Environments (FAME) studies have shown some extremely long foraging trips for kittiwakes (as reported in various publications such as Fair Isle Bird Observatory annual reports). However, those extreme values tend to occur at colonies where food supply is extremely poor and breeding success is low (for example Orkney and Shetland). Daunt et al. (2002) point out that seabirds, as central place foragers, have an upper limit to their potential foraging range from the colony, set by time constraints. For example, they assess this limit to be 73km for kittiwake based on foraging flight speed and time required to catch food, based on observations of birds from the Isle of May. This means that kittiwakes would be unable to consistently travel more than 73km from the colony and provide enough food to keep chicks alive. Hamer et al. (1993) recorded kittiwake foraging ranges exceeding 40km in 1990 when sandeel stock biomass was very low and breeding success at the study colony in Shetland was 0 chicks per nest, but <5km in 98% of trips in 1991 when sandeel abundance was higher and breeding success was 0.98 chicks per nest. Kotzerka et al. (2010) reported a maximum foraging range of 59km, with a mean range of around 25km for a kittiwake colony in Alaska. On the basis of results from the above studies, the array areas are probably too far away from the Flamborough and Filey Coast SPA colonies to sustain successful provisioning of chicks.

1312. A considerable amount of tracking information has been collected for kittiwakes breeding in the Flamborough and Filey Coast SPA colonies over the past 20 years which provides information on the likely strength of breeding season connectivity with the array areas. This is examined in further detail below.

1313. A second, and in many ways most likely option, is that the birds originate from the two relatively small colonies that are considerably closer to the array areas. The closest of these is on two artificial rigs off the Sizewell coast, just 29 km to the west of the closest part of the array areas. This is reported to have held 502 AON (equivalent to pairs) in 2018, the most recent count (SMP 2022). The other relatively nearby colony is on buildings at Lowestoft harbour 53km to the north north-west of the closest part of the array areas and which is reported to have held 446 AON in 2018, the most recent count (SMP 2022). No tagging data have been collected for kittiwakes breeding in the Lowestoft or Sizewell colonies. However, the distance from these colonies to all parts of the array areas is clearly well within the typical foraging range of breeding kittiwakes (Woodward *et al*., 2019). Applying the apportioning methodology (SNH, 2018; using in this case colony size and distance weightings), estimates that 49% of the predicted adult kittiwake collision mortality in the array areas during the breeding season would involve birds from the SPA (Table 7.13).

1314. A third possibility is that some of the adult-plumaged birds recorded at the array areas in the breeding season were not actively breeding. Kittiwakes adopt adult plumage by their third year but (on average) do not start to breed until four years old (Coulson 2011), and so a proportion of birds recorded in adult plumage during offshore surveys will be immatures. Additionally, the review of seabird demographic parameters by Horswill and Robinson (2015) estimates that 18.0 – 20.8% of adult kittiwakes opt out of breeding in a given year. Although there is no tracking data for adults that take such a 'sabbatical year' they would clearly not be subject to the same spatial constraints as actively breeding birds, and therefore might be more likely to exploit foraging grounds that lie beyond the typical foraging range of actively breeding birds. The whole-colony count at Flamborough and Filey Coast in 2017 reported about 5,000 non-breeding kittiwakes in attendance, many on potential nest territories (Clarkson et al. 2022).

1315. Kittiwakes recorded in the array areas during the breeding season may also include sub-adult birds, as well as breeding and sabbatical adults. The mean percentage of kittiwakes identified as adults during monthly baseline surveys in the breeding season (March to August) was 84% from the sample of records for which the age class could be determined (PEIR Appendix 13.2, Volume III). On average it was not possible to age 45% of kittiwakes recorded during breeding season months. Nevertheless, these observations indicate that a proportion of birds recorded during the breeding season were sub-adults. On this basis it is assumed that adult birds would make up 84% of collisions victims during the breeding season.

Table 7.13 Counts of breeding kittiwake at Flamborough and Filey Coast SPA, Sizewell Rigs and Lowestoft and breeding season apportioning of adult birds for North Falls

Site	No. Pairs	Year	Distance North Falls (km)[1]	Colony weight[2]	Distance weight[2]	Combined Weight[2]	Percentage of birds at North Falls
Sizewell Rigs	502	2018	29	0.010	146.5	1.401	41 %
Lowestoft	446	2018	53	0.008	43.9	0.373	11 %
Flamborough and Filey	51,535	2017	269	0.982	1.7	1.672	49 %
Totals	52,483		351			3.446	

1. Distances as given in text.

2. The likely proportion of birds from each breeding site at North Falls during the breeding season estimated based on SNH (2018) apportioning guidance. Colony weighting = site population (individuals) / sum of site populations (individuals); distance weighting = (sum of site distances)^2 / (site distance)^2; combined weight = colony weight x distance weight; % of birds from site a North Falls = combined site weighting / sum of combined site weight x 100.

1316. Returning to the issue of foraging range, Woodward *et al*. (2019) include summary foraging range metrics for three breeding kittiwake tracking studies conducted within the Flamborough and Filey Coast SPA and involving a total 163 individual adults. Given the existence of this site-specific data, it is valuable to consider the extent to which they support the conclusion regarding the potential for breeding season connectivity between the SPA and the array areas as determined by the generic foraging range metrics based on data from all colonies. The site specific foraging metrics are summarised below.

1317. The mean foraging distance of the 163 birds tracked from the Flamborough and Filey Coast SPA was 103 km and only one of the birds had a foraging trip recorded at a distance exceeding 300km from the colony. Of the 102 birds tracked from Bempton Cliffs colony, the furthest distance travelled to a foraging location was 227km and the mean distance was 86km. Similarly of 52 birds tracked from the Filey colony the maximum distance travelled to a foraging location was 212km and a mean distance was 118km. None of the Bempton or Filey birds foraged further south than Lincolnshire, with the great majority of birds flying out on bearings between NE and east south east (ESE); North Falls is on a bearing slight south of SE. The results for the 9 individuals tracked from Flamborough Head colony were similar to those for Bempton and Filey in terms of direction but these birds but tended to travel further with a mean foraging distance of 200km and maximum foraging distance of 317km. However, none of these birds were recorded foraging off the East Anglia coast further south than Lowestoft.

1318. Tracking showed that none of the track routes of the 163 birds studied either overlapped, or came within approximately 100 km of the array areas. Only one bird of the tracked individuals recorded a maximum foraging distance that would have been sufficient to reach the array areas but this bird targeted foraging grounds to the east of Flamborough Head. Not only were the distances travelled to foraging locations generally well below the distance to the array areas, but also the flight routes taken by birds were not in the direction of the array areas. Similarly (and as expected based upon the above details), the modelled foraging distributions of breeding kittiwake from the Flamborough and Filey Coast SPA, as derived from tracking data, show that the predicted areas of usage are distant from the array areas (Cleasby et al. 2018).

1319. Although these tracking data are to a large extent limited to the chick-rearing period (as opposed to encompassing the full breeding season), they provide little, or no, evidence to suggest that kittiwakes from the Flamborough and Filey Coast SPA will make use of the array areas during the breeding season and it is concluded that breeding kittiwakes from Flamborough and Filey Coast SPA are unlikely to forage in there. However, there is clearly a small possibility that occasionally, for example in years when food availability is low, a small proportion of individuals could forage in the northern part of the array areas.

Non-breeding season

1320. Adult kittiwakes (and juveniles) desert their breeding colony as soon as their chicks fledge, which typically happens in the last week of July or the first week of August. At the same time fledglings become independent of their parents. Freed from the constraint of colony attendance, kittiwakes typically disperse away from the colony. Evidence from numbered metal rings and geo-location tags put on kittiwakes at their breeding colonies show that there is considerable variability between individuals in the extent, timing and rate of post-breeding movements (Frederiksen *et al*., 2012; Wernham, 2003). At one extreme, birds from east coast colonies have been recorded on the Newfoundland Banks off Canada (approximately 4,000 km to the west) before the end of August, whereas other birds may stay within the region through the autumn and winter. Throughout the non-breeding period kittiwakes are free to wander widely, and most live an essentially pelagic life frequenting areas with suitable food supplies. The ringing and tagging data also shows that there is a considerable mixing of birds from different breeding areas, with the North Sea hosting wintering birds from breeding colonies in eastern UK, Scandinavia, Spitzbergen and the Barents Sea (Frederiksen *et al*. 2012; Wernham, 2003).

1321. For the purposes of apportioning effects during the non-breeding periods (i.e. the autumn and spring passage periods – Furness 2015), the BDMPS approach is used (Furness 2015). This assumes that birds (of all age classes) associated with breeding colonies in the UK and elsewhere in northern Europe contribute birds to the relevant BDMPS population, which in this case is determined to be the UK North Sea. This population is estimated to comprise 829,937 individuals of all ages during autumn passage (August to December) and 627,816 individuals of all ages during spring passage (January to April), based upon the proportions of adult and immature birds from the different contributory breeding colonies and populations which are estimated to occur within the UK North Sea during these periods (Furness 2015). It is assumed that birds of all age classes from the different contributory colonies and populations are evenly distributed throughout the BDMPS. Thus, during the autumn migration season, 60% of the Flamborough and Filey Coast SPA breeding adults are assumed to be present in the BDMPS together with 40% of the immatures nominally associated with the SPA, representing 5.4% and 3.2% of the BDMPS population; and during the spring migration season, 60% of SPA breeding adults are also assumed to be present in the BDMPS together with 30% of the immatures nominally associated with the SPA, representing 7.2% and 3.2% of the BDMPS population, respectively.

7.4.3.1.3 Effect: Collision risk (kittiwake)

1322. Mortality from collision with WTGs is considered to be the only impact from the project that would affect kittiwakes. The magnitude of this risk to individual SPA qualifying kittiwake population is examined through collision risk modelling (CRM) to estimate how many birds may potentially be killed and apportioning this mortality between colonies according to potential connectivity (as discussed earlier) and across age classes (adult or immature).

1323. The details of the CRMs that have been undertaken to predict collision mortality of kittiwakes at the North Falls site are presented in PEIR Chapter 13 Volume I, Section 13.6.2.2 and PEIR Volume III, Appendix 13.2. The stochastic version of the model was used to predict mortality for three different design scenarios (1a, 1b and 2), based on the mean monthly densities of birds in flight within the array areas. Outputs were based on Option 2 of the model which uses the generic flight height data (Johnston et al. 2014a and b) and assumes a uniform distribution of flight heights across the rotor swept zone. CRMs were run for nocturnal activity factors (NAF) of 25% and 50%), with other input parameters as agreed with Natural England. For the purposes of informing the RIAA, the models that use a NAF of 25% are considered the most appropriate as empirical evidence indicates that a NAF of 25% is more realistic than an NAF of 50%. Furness et al. (in prep., cited in Royal HaskoningDHV, 2019b) identified nocturnal activity rates for the breeding and non-breeding seasons respectively of 20% and 17% based on empirical evidence.

1324. An avoidance rate of 98.9% was applied to these CRM outputs, with this being the currently recommended value for kittiwake when using Option 2 of the CRM (SNCBs 2014). Natural England’s (2022c) interim advice on CRM parameters recommends that the avoidance rate for kittiwake is increased from 98.9% (98.7-99.1) to 99.2 (±0.03). Although this guidance was received after CRM was completed for the North Falls PEIR, it’s application would reduce the predicted collision risk for this species from North Falls by 27%.

1325. The predicted total mortality from the CRMs are similar for each of the three scenarios examined, with total annual mortality (i.e. all age groups) ranging from a mean of 28.7 to 42.6 birds per annum, and a mean of 6.1 to 10.7 collisions per annum apportioned to breeding adults from the SPA (Table 7.14).

Table 7.14 Seasonal and annual collisions for kittiwake at North Falls apportioned to the Flamborough and Filey Coast SPA (breeding adults) and increase in SPA population mortality rates (grey shading indicates worst case scenario)

WTG scenario	Nocturnal activity factor	Statistic	Apportioning[1]	Predicted collisions (sCRM)				Annual collisions as % increase in SPA population mortality rate[2]
				Aut-mig	Spr-mig	Breed-full	Annual	
1a	0.25	Mean	All	7.5	12.23	14.60	34.33	-
			Apportioned to SPA	0.41	0.88	6.03	7.32	0.0
		LCI	All	2.68	2.82	4.89	10.39	-
			Apportioned to SPA	0.14	0.20	2.02	2.37	0.0
		UCI	All	13.74	24.13	26.73	64.59	-
			Apportioned to SPA	0.74	1.74	11.04	13.52	0.1
	0.5	Mean	All	9.85	15.53	16.91	42.29	-
			Apportioned to SPA	0.53	1.12	6.99	8.64	0.1
		LCI	All	3.53	3.85	5.90	13.29	-
			Apportioned to SPA	0.19	0.28	2.44	2.91	0.0
		UCI	All	17.61	30.89	30.26	78.76	-
			Apportioned to SPA	0.95	2.22	12.50	15.68	0.1
1b	0.25	Mean	All	9.29	15.3	18.05	42.64	-
			Apportioned to SPA	0.50	1.10	7.46	9.06	0.1
		LCI	All	3.13	4.06	6.03	13.22	-
			Apportioned to SPA	0.17	0.29	2.49	2.95	0.0
		UCI	All	16.67	30.52	32.97	80.16	-
			Apportioned to SPA	0.90	2.20	13.62	16.72	0.1
	0.5	Mean	All	12.27	19.07	20.97	52.31	-
			Apportioned to SPA	0.66	1.37	8.66	10.70	0.1
		LCI	All	4.47	4.42	6.87	15.76	-

WTG scenario	Nocturnal activity factor	Statistic	Apportioning[1]	Predicted collisions (sCRM)				Annual collisions as % increase in SPA population mortality rate[2]
				Aut-mig	Spr-mig	Breed-full	Annual	
			Apportioned to SPA	0.24	0.32	2.84	3.40	0.0
		UCI	All	22.11	38.05	37.67	97.83	-
			Apportioned to SPA	1.19	2.74	15.56	19.50	0.1
2	0.25	Mean	All	6.25	10.3	12.15	28.69	-
			Apportioned to SPA	0.34	0.74	5.02	6.10	0.0
		LCI	All	2.29	2.82	3.96	9.07	-
			Apportioned to SPA	0.12	0.20	1.64	1.96	0.0
		UCI	All	11.12	20.08	22.11	53.32	-
			Apportioned to SPA	0.60	1.45	9.13	11.18	0.1
	0.5	Mean	All	8.24	13.35	14.11	35.7	-
			Apportioned to SPA	0.44	0.96	5.83	7.24	0.0
		LCI	All	2.97	3.51	4.82	11.3	-
			Apportioned to SPA	0.16	0.25	1.99	2.40	0.0
		UCI	All	15.02	26.44	25.56	67.02	-
			Apportioned to SPA	0.81	1.90	10.56	13.27	0.1

1. SPA apportioning of predicted collisions at North Falls: autumn migration 5.4%, spring migration 7.2%, breeding 49% of adults (with adult birds estimated to represent 84% of birds recorded in breeding season baseline surveys from plumage characteristics).

2. Based on annual adult mortality of 0.146 (PEIR Chapter 13 Volume I, Table 13.13)

7.4.3.1.4 Project alone assessment

1326. The assessment assumes on a precautionary basis that the array areas are within the breeding season foraging range of birds from the Flamborough and Filey Coast SPA colonies. During the breeding season it is assumed that 84% of collisions involve adult birds (based on the proportions recorded in baseline surveys, paragraph 1315), and of these 49% derive from the SPA.

1327. During the autumn and spring migration periods, the proportion of collisions in the array areas affecting the SPA population of breeding adults is estimated based on the predicted contribution to the BDMPS (paragraph 1321 above).

1328. Annual predicted mortality from collisions in the array areas is given in Table 7.14, for the three scenarios and nocturnal activity factors of 0.25 and 0.5. The table also shows the equivalent increases in population mortality of breeding adults for collisions predicted under each scenario, based on an assumed baseline annual adult mortality rate of 14.6% (Horswill and Robinson, 2015). In all cases, including the worst case scenario (1b, 50% NAF, mean and upper confidence limits) collisions from North Falls are predicted to increase the SPA population mortality by 0.1% or less.

1329. At these levels no detectable effects on the SPA population of breeding adults would be expected. The predicted change is well below the nominal 1% change threshold considered appropriate for triggering additional assessment analysis such as undertaking population viability modelling.

1330. It is therefore concluded that collision mortality of kittiwakes caused by North Falls alone would not adversely affect the integrity of Flamborough and Filey Coast SPA.

1331. The confidence in this assessment is considered to be high on the basis that the site-specific and generic information used to define CRM is of high quality and of recent origin, that WTG collision avoidance behaviour by this species is increasingly well understood, and there is a good year-round understanding of the potential for connectivity between individuals from this SPA and the array areas. The consideration of the worst case development scenario (Scenario 1b) and the adoption of a precautionary approach where appropriate (e.g., regarding aspects of the birds' foraging behaviour) also adds confidence that collision risk is not underestimated and that the conclusion is robust. The conclusion of the assessment is the same irrespective of whether the mean or upper 95% confidence estimate of flying bird densities are used to estimate collision mortality, providing further confidence in the conclusion.

1332. As stated above, Natural England's (2022c) interim advice on CRM parameters recommends that the avoidance rate for kittiwake is increased from 98.9% (98.7-99.1) to 99.2 (±0.03). Although this guidance was received after CRM was completed for the North Falls PEIR, its application would reduce the predicted collision risk for this species from North Falls by 27% and consequently reduce the predicted project alone mortality of the SPA breeding population.

7.4.3.1.5 In-combination assessment

1333. The in-combination assessment considers the combined predicted collision risk to kittiwakes at the Flamborough and Filey Coast SPA from OWFs within foraging range during the breeding season, and within the UK North Sea BDMPS (Furness 2015) during the spring and autumn migration seasons. In each season the predicted collision risk from OWFs within the area of search is apportioned to the SPA. In combination seasonal and annual totals are set out in Table 7.15.

1334. For North Falls, the collision risk predictions for the worst case-scenario (scenario 1b, 50% NAF) are used (Table 7.14). The in-combination totals for the other OWFs derive from the material used for the submission of the Dudgeon Extension and Sheringham Shoal Extension projects (Royal HaskoningDHV, 2022a), in turn based largely on the Deadline 11 updates for East Anglia ONE North and TWO, MacArthur Green and Royal HaskoningDHV 2021c). It is recognised that there have been subsequent updates to these in-combination totals (notably as published during the DCO Examination for Hornsea Project Four) but the differences are relatively minor, and the data presented in Table 7.15 are considered sufficient for the purposes of informing the North Falls PEIR (and will be revised subsequently).

1335. The potential collision mortalities presented in Table 4 are based largely on consented designs, which represents a highly precautionary position because for many of these projects the actual as-built designs are associated with lower potential collision mortality (e.g, because fewer WTGs are included in the final built design than are considered for the worst-case consented design). Previous estimates indicate that basing the in-combination numbers on the estimates as derived from the as-built designs can reduce the totals by at least 40% (MacArthur Green 2017). However, whilst the as-built designs represent the most realistic scenario in terms of the existing collision risk, these are not considered by some stakeholders to be legally secured (at least for projects in English waters), so there is a theoretical (albeit highly unlikely) possibility of further WTG construction on such project sites (The Crown Estate and Womble Bond Dickinson 2021).

1336. In addition, to the in-combination totals relying on the consented designs, other elements of precaution include the fact that the collision mortality estimates will be based largely on an assumed 50% NAF (whereas the best available evidence suggests rates of approximately 20% are more likely – see above, MacArthur Green 2019). They are also calculated on the basis of a 98.9% avoidance rate and the recent interim advice from Natural England indicates that changes to the recommended avoidance rate for kittiwake will reduce these collision totals by 27% (see above).

Table 7.15 In combination collision risk for kittiwake at the Flamborough and Filey Coast SPA

Tier	OWF	Overlap with foraging range from Flamborough and Filey Coast [1]		Predicted number of collisions (in total and apportioned to SPA[2])								Consented subject to compensation for kittiwake at Flamborough and Filey Coast
		MMFR 1SD (300.6km)	MMFR (156.1km)	Autumn migration		Spring migration		Breeding		Annual		
				Total	SPA	Total	SPA	Total	SPA	Total	SPA	
1	Beatrice Demonstrator	No	No	2.1	0.1	1.7	0.1	0	0	3.8	0.2	
1	Beatrice	No	No	10.7	0.6	39.8	2.9	94.7	0	145.2	3.4	
1	Blyth Demonstration	Yes	Yes	2.3	0.1	1.4	0.1	1.7	1.7	5.4	1.9	
1	Dudgeon	Yes	Yes	0	0	0	0	0	0	0	0	
1	East Anglia ONE	Yes	Yes	160.4	8.7	46.8	3.4	1.8	1.8	209.2	13.8	
1	EOWDC (Aberdeen)	No	No	5.8	0.3	1.1	0.1	11.8	0	18.7	0.4	
1	GWF	Yes	No	27.8	1.5	31.8	2.3	6.3	3.2	65.9	6.9	
1	GGOW	Yes	No	15	0.8	11.4	0.8	1.1	0.6	27.5	2.2	
1	Gunfleet Sands	Yes	No	0	0	0	0	0	0	0	0	
1	Hornsea Project One	Yes	Yes	55.9	3.0	20.9	1.5	44	36.5	120.8	41.0	
1	Hornsea Project Two	Yes	Yes	9	0.5	3	0.2	16	13.3	28	14.0	
1	Humber Gateway	Yes	Yes	3.2	0.2	1.9	0.1	1.9	1.9	7	2.2	
1	Hywind	No	No	0.9	0	0.9	0.1	16.6	0	18.3	0.1	
1	Kentish Flats and Extension	Yes	Yes	0.9	0	3.4	0.2	0	0	4.3	0.3	
1	Kincardine	No	No	9	0.5	1	0.1	22	0	32	0.6	
1	Lincs	Yes	Yes	1.2	0.1	0.7	0.1	0.7	0.7	2.6	0.8	
1	London Array	Yes	Yes	2.3	0.1	1.8	0.1	1.4	0.7	5.5	1.0	
1	Lynn and Inner Dowsing	Yes	Yes	0	0	0	0	0	0	0	0	
1	Methil	Yes	No	0	0	0	0	0.4	0	0.4	0	

Tier	OWF	Overlap with foraging range from Flamborough and Filey Coast [1]		Predicted number of collisions (in total and apportioned to SPA[2])								Consented subject to compensation for kittiwake at Flamborough and Filey Coast
		MMFR 1SD (300.6km)	MMFR (156.1km)	Autumn migration		Spring migration		Breeding		Annual		
				Total	SPA	Total	SPA	Total	SPA	Total	SPA	
1	Moray East	No	No	2	0.1	19.3	1.4	43.6	0	64.9	1.5	
1	Race Bank	Yes	Yes	23.9	1.3	5.6	0.4	1.9	1.9	31.4	3.6	
1	Rampion	No	No	37.4	2.0	29.7	2.1	54.4	0	121.5	4.2	
1	Scroby Sands	Yes	No	0	0	0	0	0	0	0	0	
1	Sheringham Shoal	Yes	Yes	0	0	0	0	0	0	0	0	
1	Teeside	Yes	Yes	24	1.3	2.5	0.2	38.4	38.4	64.9	39.9	
1	Thanet	Yes	Yes	0.5	0	0.4	0	0.2	0	1.1	0.1	
1	Triton Knoll	Yes	Yes	139	7.5	45.4	3.3	24.6	24.6	209	35.4	
1	Westermost Rough	Yes	Yes	0.2	0.0	0.1	0.0	0.1	0.1	0.5	0.1	
2	Dogger Bank A and B	Yes	Yes	135	7.3	295.4	21.3	288.6	55.8	719	84.4	
2	Dogger Bank C and Sofia	Yes	Yes	90.7	4.9	216.9	15.6	136.9	26.4	444.5	46.9	
2	Seagreen Alpha and Bravo	Yes	No	313.1	16.9	247.6	17.8	153.1	0	713.8	34.7	
2	Moray West	No	No	24	1.3	7	0.5	79	0	110	1.8	
2	Neart na Gaoithe	Yes	No	56.1	3.0	4.4	0.3	32.9	0	93.4	3.3	
3	East Anglia ONE North	Yes	Yes	8.1	0.4	3.5	0.3	40.4	20.2	52	20.9	Yes
3	East Anglia THREE	Yes	Yes	56.6	3.1	30.7	2.2	4.9	2.5	92.3	7.7	
3	East Anglia TWO	Yes	Yes	5.4	0.3	7.4	0.5	29.5	14.8	42.3	15.6	Yes
3	Hornsea Project Three	Yes	Yes	38	2.1	8	0.6	77	72.0	123	74.6	Yes
3	Inch Cape	Yes	No	224.8	12.1	63.5	4.6	13.1	0	301.4	16.7	
3	Norfolk Boreas	Yes	No	32.2	1.7	11.9	0.9	13.3	11.4	57.5	14.0	Yes

Tier	OWF	Overlap with foraging range from Flamborough and Filey Coast [1]		Predicted number of collisions (in total and apportioned to SPA[2])								Consented subject to compensation for kittiwake at Flamborough and Filey Coast
		MMFR 1SD (300.6km)	MMFR (156.1km)	Autumn migration		Spring migration		Breeding		Annual		
				Total	SPA	Total	SPA	Total	SPA	Total	SPA	
3	Norfolk Vanguard	Yes	No	16.4	0.9	19.3	1.4	21.8	18.7	57.5	21.0	Yes
4	Hornsea Project Four	Yes	Yes	13.9	0.8	4.6	0.3	74.5	70.3	93	71.4	
4	Dudgeon Extension	Yes	Yes	4.6	0.2	1.3	0.1	9.1	9.1	15	9.4	
4	Sheringham Shoal Extension	Yes	Yes	1.2	0.1	0	0	0.8	0.8	2	0.9	
5	North Falls	Yes	No	12.3	0.7	19.1	1.4	21.0	8.6	52.3	10.7	
TOTALS				**1566**	**85**	**1211**	**87**	**1379**	**435**	**4157**	**607**	
TOTAL excluding sites with compensation measures											**461**	

1. Foraging ranges from Woodward et al. 2019.

2. For all OWFs the seasonal and total numbers of collisions for each OWF is as in MacArthur Green and Royal HaskoningDHV (2021), except for North Falls (Section 7.4.3.1.2 above), Dudgeon and Sheringham Shoal extensions (Royal HaskoningDHV, 2022a) and Hornsea Project Four (APEM and GoBe Consultants 2022; Natural England approach). During autumn and spring migration apportioning is based on the Flamborough and Filey Coast SPA population as a proportion of the UK North Sea BDMPS, respectively 0.054 and 0.072 (Furness 2015). Breeding season apportioning of the Flamborough and Filey Coast population for North Falls is as described in Section 7.4.3.1.4 above. For other OWFs within MMFR (156.1km) the numbers apportioned to the SPA are as MacArthur Green and Royal HaskoningDHV (2021c) except for Dudgeon and Sheringham Shoal extensions (Royal HaskoningDHV, 2022a) and Hornsea Project Four (APEM and GoBe Consultants 2022, Natural England approach). For OWFs within MMFR+1SD but not MMFR, 50% of collisions are apportioned to Flamborough and Filey Coast SPA on a precautionary basis, except for North Falls (see Section 7.4.3.1.2 above) Norfolk Boreas and Norfolk Vanguard (taken from MacArthur Green and Royal HaskoningDHV 2021c) and sites in the outer Firths of Forth and Tay, where zero collisions are apportioned to Flamborough and Filey Coast as it is considered highly unlikely that there is breeding season connectivity with the SPA.

1337. Based upon the data in Table 4, the potential collision mortality of kittiwakes from the Flamborough and Filey Coast SPA due to North Falls in-combination with other OWFs equates to 607 adult birds without accounting for developments consented with compensatory measures for kittiwakes, and 461 adult birds with the compensatory measures taken into account. North Falls contributes 10.7 birds, representing 2.3% of the in-combination total when the existing compensatory measures are taken into account.

1338. An annual collision mortality of 461 adult birds would increase the baseline mortality rate of the SPA breeding kittiwake population by 3.5%, based on a population size of 89,148 adults (Clarkson et al. 2022) and a baseline mortality rate of 0.146 (Horswill and Robinson 2015). Such an increase is of sufficient magnitude to potentially result in a detectable impact at the population level. Given this, PVA outputs are used to further assess the potential population level impact. For the purposes of the North Falls PEIR, the PVAs for the Flamborough and Filey Coast SPA kittiwake population which were produced to inform the Hornsea Project Three OWF are used (MacArthur Green 2018) but it is proposed to update these with PVAs specific to the North Falls project, subsequent to the PEIR.

1339. A number of different PVAs for the SPA kittiwake population were produced for the Hornsea Project Three OWF, with each of these considering the potential effects of additional adult mortality over a 35-year period, with the additional mortality applied in increments of 50 birds up to a maximum of 1600. Outputs included the two key metrics which are recommended for use in interpretating PVAs on the basis that they have relatively low sensitivity to factors such as varying population status and the mis-specification of the demographic rates underpinning the population model (Cook and Robinson 2015, Jitlal *et al.,* 2017). These metrics are:

- The CPS - the median of the ratio of the end-point size of the impacted to un-impacted (or baseline) population, expressed as a proportion.
- The CPGR - the median of the ratio of the annual growth rate of the impacted to un-impacted population, expressed as a proportion.

1340. The current assessment focusses on the outputs from the PVA which is based upon a density independent population model, using demographic rates as specified in Horswill and Robinson (2015) (i.e. demographic rate set 2 in MacArthur Green 2018, 2015) and which was undertaken using a matched runs approach. The key outputs from this PVA are found in Table 7.16.

1341. On the basis of this PVA, an additional mortality of 461 adult birds per annum gives CPS and CPGR values of approximately 0.842 and 0.995, respectively. Therefore, the potential in-combination collision mortality is predicted to result in a population size which is 16% smaller after 35 years than it would be under baseline conditions (i.e. without the additional mortality from collisions). This predicted population level impact needs to be considered within the context of a highly precautionary assessment, which (amongst other factors) relies upon estimates for consented rather than as-built designs and on an avoidance rate which recent interim advice suggests should be increased in accordance with the available evidence (see above).

Table 7.16 Population modelling results for kittiwake at Flamborough and Filey Coast: counterfactuals of population growth rate and size for models including and excluding predicted mortality from collision and displacement from OWFs

Model	Adult Mortality	Counterfactual metric (after 35 years)		Source (MacArthur Green 2018)
		Population size (CPS)	Median growth rate (CPGR)	
Density independent	450	0.842	0.995	Table A2_7.1, A2_7.3
	500	0.827	0.994	
Density dependent	450	0.955	0.999	Table A2_8.1, A2_8.3
	500	0.950	0.999	

1342. In addition, it is important to consider that the above CPS and CPGR metrics are derived from a density independent population model, which assumes no population regulation (and, as such, is biologically implausible). As a consequence, the resulting PVA is likely to give overly precautionary outputs because it does not allow for the operation of compensatory density dependence to offset (to some degree at least) the additional mortality from collisions (e.g. Horswill *et al.* 2016). Outputs from a PVA based on a density dependent (but otherwise equivalent) population model give CPS and CPGR values of approximately 0.955 and 0.999, respectively, for an additional annual mortality of 461 adult birds (MacArthur Green 2018). This equates to the SPA population being just 5% smaller after 35 years than it would be under baseline conditions, illustrating the potentially high levels of precaution that may result from relying solely on density independent population models in the assessment.

1343. The Conservation Objectives for the Flamborough and Filey Coast SPA kittiwake population include a target to restore the population size to 83,700 breeding pairs, which is more than one and half times the current population size. This is despite the uncertainty over the veracity of the evidence pertaining to size of this population in the late 1980s and, hence, the long-term status of the population (as detailed above). If the evidence on the population size in the late 1980s is accepted, it is considered that the population level impacts predicted to result from the potential collision mortality from North Falls in-combination with other OWFs (and as determined on the basis of a density independent population model) have the potential to prevent this objective being achieved. Consequently, it is concluded that an adverse effect as a result of collision mortality from North Falls in-combination with other OWFs cannot be excluded.

1344. The above conclusion is consistent with those reached in relation to the Flamborough and Filey Coast SPA kittiwake population in recent DCO Examinations for other OWFs in English North Sea waters. At the same time, it is considered important to view this conclusion within the context of the precautionary nature of the assessment, and also the recent increase in avoidance rate advised by Natural England on the avoidance rate for kittiwake, from 98.9% (98.7-99.1) to 99.2 (±0.03), which would reduce the in-combination collision risk by approximately 27%. In addition, achievement of the 'restore' target for the SPA population represents a major challenge (irrespective of the predicted impact from the in-combination collision mortality) because it requires the impacts from both fisheries management and climate change to be addressed (these being the factors of greatest importance in determining the status of kittiwake populations in the North Sea - Frederiksen *et al.* 2004, Carroll *et al.* 2017).

1345. Thus, the RIAA presented in the PEIR for North Falls is accompanied by a report outlining potential compensation measures for kittiwake at the Flamborough and Filey Coast on a without prejudice basis.

7.4.3.2 Guillemot

1346. This species has been screened in for appropriate assessment in relation to operational displacement / barrier effect during the breeding and non-breeding seasons.

7.4.3.2.1 Status

1347. The Flamborough and Filey Coast SPA breeding guillemot population was cited as 41,607 pairs (or 83,214 breeding adults) (based on the mean count of individuals present on land during the period 2008-2011 (SMP and RSPB counts) of 62,100 individuals, multiplied by correction factor 0.67 to translate to number of breeding pairs to account for birds away from colony). A whole-colony count for the SPA in 2017 reported 60,877 pairs (or 121,754 breeding adults) (Aitken et al. 2017). The most recent whole-colony count for the SPA (in 2022) was 74,989 pairs (or 149,978 breeding adults) (Clarkson *et al.* 2022) using the same methodology. The population trend from field counts of individuals shows an average annual increase of almost 3.5% from 1987 to 2022 (with the field counts at the Flamborough Head and Bempton Cliffs colony, which holds the bulk of the SPA population, increasing over threefold from ~30,000 to ~100,000 during this period). The SPA population has shown a consistently increasing trend since at least the 1960s (Clarkson *et al.* 2022). SACOs(Natural England 2020) set a target to maintain the size of the breeding population at a level which is above 41,607 breeding pairs. whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.

7.4.3.2.2 Functional Linkage and Seasonal Apportionment of Potential Effects

Breeding season

1348. North Falls is 266km from the Flamborough and Filey Coast SPA boundary at the nearest point. Based on data from all of the individual tracking studies included in the latest review of such studies by Woodward *et al*. (2019), the mean-maximum foraging range of guillemot is estimated as 73.2km (± 80.5km SD). The maximum foraging range across reviewed studies is 338km (Woodward *et al*. 2019). Excluding data from breeding guillemots at Fair Isle, where reduced prey availability was considered to have significantly increased foraging ranges during the breeding seasons in which tracking was undertaken, the mean-maximum foraging range is 55.7km (±39.7km S.D.) and the maximum is 135km (Woodward *et al*. 2019). Natural England have indicated that it is reasonable to exclude the extreme Fair Isle values when considering the potential breeding season foraging range for the Flamborough and Filey Coast

SPA guillemot population (Natural England 2022b). The mean-maximum breeding season foraging range of guillemot in the previous review of seabird foraging ranges (Thaxter *et al.* 2012) was 84.2km (±50.1km S.D.) based on data from six sites. The more recent review, based on data from 16 sites, therefore estimates a smaller mean-maximum foraging range (Woodward *et al.* 2019).

1349. North Falls is therefore beyond the mean maximum breeding season foraging range + 1 S.D. of guillemots from the Flamborough and Filey Coast SPA (noting that the mean maximum foraging range plus 1 S.D. is a key measure for determining connectivity with SPA breeding seabird populations– Natural England 2022a). On this basis, no effect is expected to occur on the SPA population in the breeding season.

1350. Modelled at-sea distributions of breeding adults, from tracking data collected during the breeding season from foraging breeding adult individuals (Cleasby et al. 2018, 2020; Wakefield et al. 2017), also suggest that North Falls is outside the home foraging range (i.e., beyond the 95% utilisation distribution) of guillemots from the Flamborough and Filey Coast SPA. On this basis, while there is a possibility of individual breeding adult guillemots being present within the North Falls footprint during the breeding season, the modelling strongly suggests that the vast majority of guillemots recorded at the North Falls footprint during the breeding season are unlikely to be breeding adults from Flamborough and Filey Coast SPA.

1351. North Falls is not within foraging range of breeding guillemots from any other SPA (or indeed non-SPA) colonies (Mitchell *et al.* 2004). Therefore, based on the above foraging range data and utilization distribution modelling, it is likely that the birds recorded at North Falls during the breeding season are non-breeding adults or sub-adult birds which have not yet reached breeding age. This may include birds from Flamborough and Filey Coast SPA and other breeding colonies.

Non-breeding season

1352. Outside the breeding season, breeding guillemots from the SPA are assumed to range widely and to mix with guillemots of all age classes from breeding colonies in the UK and other countries. The relevant non-breeding season (August to February) reference population is the UK North Sea and Channel BDMPS (Furness 2015) consisting of 1,617,306 individuals of all age classes. During the non-breeding season, the proportion of SPA breeding adults from the Flamborough and Filey Coast SPA population contributing to the UK North Sea and Channel BDMPS is estimated from ringing and tracking data to be 0.9 (Furness 2015). Using the estimate of the SPA population of 79,282 breeding adults from the 2008 breeding season[11] (Furness 2015), the number of adults from Flamborough and Filey Coast SPA present in this non-breeding season BDMPS is estimated to be 71,354. Therefore, 4.4% of birds present at North Falls in the non-breeding season are considered to be breeding adults from the

[11]The 2008 estimate is used (as opposed to more recent estimates) because it provides an estimate which is relatively contemporary with the other national and colony population estimates from which the BDMPS population size is derived (Furness 2015).

Flamborough and Filey Coast SPA population. This is based on the SPA breeding adult population present in the BDMPS as a proportion of the total BDMPS.

1353. The mean peak guillemot population estimate at North Falls during the non-breeding season (turbine arrays + 2km buffer, the estimated zone of influence for displacement effects) is 4,497 (95% CI 1,649 - 7,781) (PEIR Volume I, Chapter 13, Table 13.16; Appendix 13.2 Volume III). Therefore, the estimated number of Flamborough and Filey Coast SPA breeding adult guillemot present at North Falls during the non-breeding season is 198 (95% CI 73 - 343).

7.4.3.2.3 Effects: displacement / barrier effect during operation

1354. For the purposes of estimating the mortality that could potentially result from displacement effects, displacement rates of 30% to 70% are considered for this species, along with a range of mortality rates from 1% to 10% of displaced birds (UK SNCBs 2017). Also, as stated in PEIR Chapter 13 Volume I (Section 13.6.2.1), for the purposes of assessment of birds present in an OWF site during a given season, it is usually not possible to distinguish between displacement and barrier effects - for example to define where individual birds may have intended to travel to, or beyond an OWF site, even when tracking data are available. Therefore, in this assessment the effects of displacement and barrier effects on guillemot are considered together.

1355. The upper values within the ranges of displacement and mortality rates are likely to be overly precautionary. The available evidence suggests that guillemots tend to be displaced from OWFs, with displacement rates varying between sites but, on average, it is considered that densities within OWFs tend to be approximately half of those occurring in the habitats around the OWF (MacArthur Green 2019). Displacement may also occur from a buffer zone around the OWF although this does not usually extend as far as 2km out from the OWF. Based on consideration of the quality of, or confidence in, the studies used to derive the recommended range of displacement rates, as well as those studies demonstrating no significant displacement, APEM (2022) suggest that a displacement rate of 50% is appropriate for guillemot.

1356. Mortality as a result of displacement could occur due to increased energy expenditure and / or decreased energy intake (e.g. from increased flight time or increased intra-specific competition associated with higher densities in foraging habitat outside OWFs). However, OWFs represent a small proportion of the available foraging habitat for guillemot in the North Sea and increases in densities outside OWFs are likely to be negligible (MacArthur Green 2019). When considered within the context of a baseline annual mortality rate (i.e. in the absence of OWF effects) for adult guillemots of 6.1% (Horswill and Robinson 2015), increases due to displacement are more likely to be at the lower range of the advised rates, if not below these (MacArthur Green 2019). Thus, based on consideration of available evidence, together with what is biologically plausible, both MacArthur Green (2019) and APEM (2022) suggest that a displacement rate of 50% and mortality rate amongst displaced birds of 1% are sufficiently precautionary.

1357. A more detailed review of the evidence in relation to displacement of auks from OWFs is included in PEIR Chapter 13 Volume I, Section 13.6.2.1.2.1.

1358. In the absence of OWF effects, the baseline mortality of the Flamborough and Filey Coast SPA breeding adult population is estimated to be 9,149 adult birds per year, based on an adult population of 149,978 breeding adults (Clarkson *et al.* 2022) and the published adult annual mortality rate of 6.1% (Horswill and Robinson 2015).

7.4.3.2.4 Project Alone assessment

1359. Based on the mean peak abundances, the annual total number of SPA breeding adults estimated to be present at North Falls and potentially subject to displacement by the North Falls project alone is 198 (95% CI 73 - 343) (with all such effects limited to the non-breeding season, as detailed above).

1360. At displacement rates of 30% to 70% and mortality rates of 1% to 10% for displaced birds, 1 to 14 SPA breeding adults would be predicted to die each year due to displacement from North Falls (with the ranges around those values as defined by the 95% CI for the mean peak abundance being: 95% LCI 0 to 5 breeding adults, 95% UCI 1 to 24 breeding adults) (Table 7.17).

1361. The above estimates of potential mortality due to displacement would cause the annual mortality rate for the Flamborough and Filey Coast SPA breeding population to increase by 0% to 0.2% due to displacement impacts from North Falls alone (with the ranges around those values as defined by the 95% CI for the mean peak abundance being: 95% LCI 0 to 0.1%; 95% UCI 0% to 0.3%) (**Table** 7.18). Using the evidence-based displacement rate of 50% and a 1% mortality rate for displaced birds annual mortality in the Flamborough and Filey Coast SPA breeding guillemot population would increase by 0% due to impacts from North Falls alone (95% CI 0 - 0%).

1362. Increases in the existing mortality rate of less than 1% are likely to be undetectable against natural variation. This means that no detectable changes in mortality rates would occur under any combination of displacement and mortality rates when the mean peak abundance estimate assessments are considered.

1363. It is concluded that predicted guillemot mortality due to operational phase displacement at North Falls alone would not adversely affect the integrity of the Flamborough and Filey Coast SPA.

Table 7.17 Displacement matrix for guillemot for the project alone. The cells show the number of predicted bird mortalities (to the nearest integer) per annum at given rates of displacement and mortality (LCI and UCI = upper and lower 95% confidence intervals). Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean	Mortality										
Displacement		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
	10%	0	0	1	1	1	2	4	6	10	16	20
	20%	0	1	1	2	2	4	8	12	20	32	40
	30%	1	1	2	2	3	6	12	18	30	48	59
	40%	1	2	2	3	4	8	16	24	40	63	79
	50%	1	2	3	4	5	10	20	30	50	79	99
	60%	1	2	4	5	6	12	24	36	59	95	119
	70%	1	3	4	6	7	14	28	42	69	111	139
	80%	2	3	5	6	8	16	32	48	79	127	158
	90%	2	4	5	7	9	18	36	53	89	143	178
	100%	2	4	6	8	10	20	40	59	99	158	198

LCI	Mortality										
Displacement		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	12	15
	30%	0	0	1	1	1	2	4	7	11	17	22
	40%	0	1	1	1	1	3	6	9	15	23	29
	50%	0	1	1	1	2	4	7	11	18	29	36
	60%	0	1	1	2	2	4	9	13	22	35	44
	70%	1	1	2	2	3	5	10	15	25	41	51
	80%	1	1	2	2	3	6	12	17	29	46	58
	90%	1	1	2	3	3	7	13	20	33	52	65
	100%	1	1	2	3	4	7	15	22	36	58	73

UCI	Mortality										
Displacement		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	21	34	55	68
	30%	1	2	3	4	5	10	21	31	51	82	103
	40%	1	3	4	5	7	14	27	41	68	110	137
	50%	2	3	5	7	9	17	34	51	86	137	171
	60%	2	4	6	8	10	21	41	62	103	164	205
	70%	2	5	7	10	12	24	48	72	120	192	240
	80%	3	5	8	11	14	27	55	82	137	219	274
	90%	3	6	9	12	15	31	62	92	154	247	308
	100%	3	7	10	14	17	34	68	103	171	274	342

Table 7.18 Displacement matrix for guillemot for the project alone. The cells show the % increase in the mortality rate of the SPA population associated with the number of predicted bird mortalities (to the nearest integer) per annum at given rates of displacement and mortality given in Table 7.17 (LCI and UCI = upper and lower 95% confidence intervals). Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean	Mortality											
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%
	20%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
	30%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.6%
	40%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.4%	0.7%	0.9%
	50%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.9%	1.1%
	60%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.3%	0.4%	0.6%	1.0%	1.3%
	70%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.8%	1.2%	1.5%
	80%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.5%	0.9%	1.4%	1.7%
	90%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.6%	1.0%	1.6%	1.9%
	100%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.6%	1.1%	1.7%	2.2%
LCI	**Mortality**											
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
	20%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%
	30%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%
	40%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.3%
	50%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
	60%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.5%
	70%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.6%
	90%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.6%	0.7%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	0.4%	0.6%	0.8%
UCI	**Mortality**											
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
	20%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.6%	0.7%
	30%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.6%	0.9%	1.1%
	40%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.3%	0.4%	0.7%	1.2%	1.5%
	50%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.6%	0.9%	1.5%	1.9%
	60%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.7%	1.1%	1.8%	2.2%
	70%	0.0%	0.1%	0.1%	0.1%	0.1%	0.3%	0.5%	0.8%	1.3%	2.1%	2.6%
	80%	0.0%	0.1%	0.1%	0.1%	0.1%	0.3%	0.6%	0.9%	1.5%	2.4%	3.0%
	90%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.7%	1.0%	1.7%	2.7%	3.4%
	100%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.7%	1.1%	1.9%	3.0%	3.7%

1364. The confidence in the assessment is high for several reasons. Firstly, the evidence used to inform the displacement rates is of high applicability and quality. Also, whilst there is limited available evidence to inform mortality rates, 1% is considered to be sufficiently precautionary based on consideration of the plausible extent of such effects within the context of the species biology. Notably, this species is not regarded as being highly specialised in its habitat requirements (Bradbury et al. 2014; Furness & Wade 2012; Garthe & Hüppop 2004), and it is therefore anticipated that displaced birds will find alternative habitat in the vast majority of cases. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI mean peak abundances are used to calculate the potential mortality and consequent increases in baseline mortality rate of the SPA adult population, with this being the case even when the overly precautionary rates of 70% displacement and 10% mortality area applied.

7.4.3.2.5 In combination assessment

1365. Seasonal and annual population estimates of breeding guillemot at all OWFs included in the in-combination assessment are presented in Table 7.19 along with the numbers apportioned to the Flamborough and Filey Coast SPA. This information was taken from the numbers presented at Deadline 11 of the DCO Examination for the East Anglia ONE North and East Anglia TWO projects (MacArthur Green and Royal HaskoningDHV 2021c) but updated with new information that has become available since then for some OWFs (see Table 7.19).

1366. The estimated annual total of breeding adult guillemots from Flamborough and Filey Coast SPA present and at risk of displacement from all OWFs within the UK North Sea BDMPS combined is 42,772 (Table 7.19). Of this total, North Falls contributes 0.5% (198 birds). Using displacement rates of 30% to 70% and mortality rates of 1% to 10% of displaced birds (UK SNCBs 2017), between 128 and 2,994 breeding adults from the Flamborough and Filey Coast SPA population are predicted to die each year (Table 7.20). Using the evidence-based displacement rate of 50% and a mortality rate for displaced birds of 1% gives an estimated 214 additional adult deaths per year, while 70% displacement and 1% mortality predicts 299.

1367. The estimated increase in mortality of Flamborough and Filey Coast SPA breeding guillemots due to in-combination displacement impacts is between 1.4% and 32.7% (based on a population size of 149,978 breeding adults and a baseline annual mortality rate of 6.1%, Horswill and Robinson 2015). Using the evidence-based displacement rate of 50% and a mortality rate for displaced birds of 1%, annual mortality in the Flamborough and Filey Coast SPA breeding guillemot population is predicted to increase by 2.3%. Considering 70% displacement and 1% mortality, the predicted increase in the SPA population mortality rate would be 3.3%. Increases in the existing mortality rate of greater than 1% could be detectable against natural variation.

Table 7.19 Seasonal and annual population estimates of all guillemots at North Falls and other OWFs included in the in-combination assessment; and breeding adult birds apportioned to Flamborough and Filey Coast SPA.

Tier	OWF	Seasonal Population At Risk Of Displacement[1]					
		Breeding		Non-Breeding		Annual	
		Total	FFC	Total	FFC	Total	FFC
1	Beatrice Demonstrator	No estimate available					
1	Beatrice	13610	0	2755	121	16365	121
1	Blyth Demonstration	1220	0	1321	58	2541	58
1	Dudgeon	334	0	542	24	876	24
1	East Anglia ONE	274	0	640	28	914	28
1	EOWDC (Aberdeen OWF)	547	0	225	10	772	10
1	GWF	305	0	593	26	898	26
1	GGOW	345	0	548	24	893	24
1	Gunfleet Sands	0	0	363	16	363	16
1	Hornsea Project One	9836	4554	8097	356	17933	4910
1	Hornsea Project Two	7735	3581	13164	579	20899	4161
1	Humber Gateway	99	99	138	6	237	105
1	Hywind	249	0	2136	94	2385	94
1	Kentish Flats and Extension	0	0	7	0	7	0
1	Kincardine	632	0	0	0	632	0
1	Lincs and Lynn and Inner Dowsing	582	0	814	36	1396	36
1	London Array	192	0	377	17	569	17
1	Moray Firth East	9820	0	547	24	1036	24
1	Race Bank	361	0	708	31	1069	31
1	Rampion	10887	0	15536	684	26423	684
1	Scroby Sands	No estimate available					

Tier	OWF	Seasonal Population At Risk Of Displacement[1]					
		Breeding		Non-Breeding		Annual	
		Total	FFC	Total	FFC	Total	FFC
1	Sheringham Shoal	390	0	715	31	1105	31
1	Teesside	267	267	901	40	1168	307
1	Thanet	18	0	124	5	142	5
1	Triton Knoll	425	425	746	33	1171	458
1	Westermost Rough	347	347	486	21	833	368
2	Dogger Bank (formerly Creyke Beck) A and B	14886	5210	16763	738	31649	5948
2	Dogger Bank C (formerly Teesside A) and Sofia (formerly Teesside B)	8494	2973	5969	263	14463	3236
2	Firth of Forth (Seagreen) Alpha and Bravo	24724	0	8800	387	33524	387
2	Moray West	24426	0	38174	1680	62600	1680
2	Neart na Gaoithe	1755	0	3761	165	5516	165
3	East Anglia ONE North	4183	0	1888	83	6071	83
3	East Anglia THREE	1744	0	2859	126	4603	126
3	East Anglia TWO	2077	0	1675	74	3752	74
3	Hornsea Project Three[2]	13374	0	19174	844	32548	844
3	Inch Cape	4371	0	3177	140	7548	140
3	Methil	25	0	0	0	25	0
3	Norfolk Boreas	7767	0	13777	606	21544	606
3	Norfolk Vanguard	4320	0	4776	210	9096	210
Total (tier 1-3 projects)		170,621	17,456	172,276	7,580	342,897	25,037
4	Hornsea Project Four[3]	9382	9382	36965	6871	46347	16253

Tier	OWF	Seasonal Population At Risk Of Displacement[1]					
		Breeding		Non-Breeding		Annual	
		Total	FFC	Total	FFC	Total	FFC
4	DEP (RIAA)[4]	3839	0	14887	655	18726	655
4	SEP (RIAA)[4]	1095	0	1085	48	2180	48
5	Rampion 2[5]	185	0	13219	582	13205	582
	North Falls	1103	0	4497	198	5600	198
Total (all projects)		186,225	26,838	242,929	15,934	429,154	42,772

Notes:

1. The preferred standard area is the OWF plus a 2km buffer, however the buffer zones included in this assessment varied between 0-4km depending on the data available. Project total and Flamborough and Filey Coast estimates follow those of East Anglia ONE N/East Anglia TWO Deadline 11 Offshore Ornithology Cumulative and In-Combination Collision Risk and Displacement Update (MacArthur Green and Royal HaskoningDHV 2021c), except where footnoted (see also Appendix 13.3, Volume III).

2. The East Anglia ONE N/East Anglia TWO Deadline 11 Offshore Ornithology Cumulative and In-Combination Collision Risk and Displacement Update (MacArthur Green and Royal HaskoningDHV 2021c) and Hornsea Project 4 Deadline 6 (APEM and Gobe Consultants 2022) revised totals for Hornsea Project Three identify 64% of the guillemots present during the breeding season as being apportioned to the Flamborough and Filey Coast SPA (i.e. 8,502 birds). However, given the project site is approximately 149km from the SPA, the apportionment undertaken for Hornsea Project Three determined that adult guillemot from the SPA were not present on the project array area during the breeding season and the apportionment value of 64% refers instead to immature birds from the SPA (see NIRAS 2019, 2021). As such, the above totals apportioned to the SPA do not include adult birds from Hornsea Three during the breeding season.

3. For Hornsea Project Four Natural England requested the non-breeding season was split into the chick rearing/moult period (August and September) with a 60% apportionment rate, and the remaining non-breeding period (October to February) with an apportionment rate of 4.4%. For the in combination assessment the non-breeding season total for Flamborough and Filey Coast in the table is a weighted mean of the Natural England approach (two months 22719 and five months 748, Deadline 6, PINS reference,A.5.5.2, version B)

4. Source: DEP SEP RIAA.

5. Source: Rampion PEIR.

Table 7.20 In combination displacement matrix for guillemot. The cells show the number of predicted bird mortalities (to the nearest integer) per annum at given rates of displacement and mortality. Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean	Mortality										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	43	86	128	171	214	428	855	1283	2139	3422	4277
20%	86	171	257	342	428	855	1711	2566	4277	6844	8554
30%	128	257	385	513	642	1283	2566	3849	6416	10265	12832
40%	171	342	513	684	855	1711	3422	5133	8554	13687	17109
50%	214	428	642	855	1069	2139	4277	6416	10693	17109	21386
60%	257	513	770	1027	1283	2566	5133	7699	12832	20531	25663
70%	299	599	898	1198	1497	2994	5988	8982	14970	23952	29940
80%	342	684	1027	1369	1711	3422	6844	10265	17109	27374	34218
90%	385	770	1155	1540	1925	3849	7699	11548	19247	30796	38495
100%	428	855	1283	1711	2139	4277	8554	12832	21386	34218	42772

Table 7.21 In combination displacement matrix for guillemot. The cells show the % increase in the mortality rate of the SPA population associated with the number of predicted bird mortalities per annum at given rates of displacement and mortality given in Table 7.20. Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean	Mortality										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0.5%	0.9%	1.4%	1.9%	2.3%	4.7%	9.4%	14.0%	23.4%	37.4%	46.8%
20%	0.9%	1.9%	2.8%	3.7%	4.7%	9.4%	18.7%	28.1%	46.8%	74.8%	93.5%
30%	1.4%	2.8%	4.2%	5.6%	7.0%	14.0%	28.1%	42.1%	70.1%	112.2%	140.3%
40%	1.9%	3.7%	5.6%	7.5%	9.4%	18.7%	37.4%	56.1%	93.5%	149.6%	187.0%
50%	2.3%	4.7%	7.0%	9.4%	11.7%	23.4%	46.8%	70.1%	116.9%	187.0%	233.8%
60%	2.8%	5.6%	8.4%	11.2%	14.0%	28.1%	56.1%	84.2%	140.3%	224.4%	280.5%
70%	3.3%	6.5%	9.8%	13.1%	16.4%	32.7%	65.5%	98.2%	163.6%	261.8%	327.3%
80%	3.7%	7.5%	11.2%	15.0%	18.7%	37.4%	74.8%	112.2%	187.0%	299.2%	374.0%
90%	4.2%	8.4%	12.6%	16.8%	21.0%	42.1%	84.2%	126.2%	210.4%	336.6%	420.8%
100%	4.7%	9.4%	14.0%	18.7%	23.4%	46.8%	93.5%	140.3%	233.8%	374.0%	467.5%

1368. Given the potential scale of the in-combination displacement mortality, PVA outputs are used to further assess the potential population level impact. For the purposes of the North Falls PEIR, the PVAs for the Flamborough and Filey Coast SPA guillemot population which were produced to inform the Hornsea Project Three OWF are used (MacArthur Green 2018) but it is proposed to update these with PVAs specific to the North Falls project, subsequent to the PEIR.

1369. A number of different PVAs for the SPA guillemot population were produced for the Hornsea Project Three OWF, with each of these considering the potential effects of additional adult mortality over a 35-year period, with the additional mortality applied in increments of 50 birds up to a maximum of 1600. Outputs included the two key metrics which are recommended for use in interpretating PVAs on the basis that they have relatively low sensitivity to factors such as varying population status and the mis-specification of the demographic rates underpinning the population model (Cook and Robinson 2015, Jitlal *et al.,* 2017). These metrics are:

- The CPS- the median of the ratio of the end-point size of the impacted to un-impacted (or baseline) population, expressed as a proportion.
- The CPGR - the median of the ratio of the annual growth rate of the impacted to un-impacted population, expressed as a proportion.

1370. The current assessment focusses on the outputs from the PVA which is based upon a density independent population model, using demographic rates as specified in Horswill and Robinson (2015) (i.e. demographic rate set 2 in MacArthur Green 2018) and which was undertaken using a matched runs approach. The key outputs from this PVA are found in Table 7.22.

1371. On the basis of this PVA, the additional in-combination mortality predicted to result from the evidence-based displacement rate of 0.500 and a mortality rate for displaced birds of 1% (i.e. 214 adult birds per annum) gives CPS and CPGR values of approximately 0.920 and 0.998, respectively (Table 7.22). Therefore, for this scenario, the potential in-combination mortality is predicted to result in a population size which is 8% smaller after 35 years than it would be under baseline conditions (i.e. without the additional mortality from displacement). Such a potential reduction in population size is considered to represent a small level of impact, and is highly unlikely to prevent achievement of the target to maintain the size of the breeding population above the citation level. whilst avoiding deterioration from its current level (as set out within the SACOs for this SPA). This is particularly the case, given that this potential level of impact is within the context of a long-term, and consistently, increasing trend in the size of the SPA population.

1372. Clearly, higher rates of displacement and mortality result in greater levels of predicted impacts and at the upper range of the advised rates (i.e. 70% displacement and 10% mortality of displaced birds), the CPS and CPGR values are markedly lower and represent a substantive potential impact. However, these higher displacement rates are not supported by the available evidence, whilst such high levels of mortality are not considered to be plausible. Thus, it is considered that levels of displacement and mortality sufficient to prevent achievement of the target to maintain the size of the breeding population above the citation level, whilst avoiding deterioration from its current level, would not occur.

Table 7.22 Values for Counterfactual Metrics Summarising Outputs from Population Viability Analyses for the Flamborough and Filey Coast SPA guillemot population in relation to the potential in-combination mortality due to displacement from OWFs

Model	Displacement scenario[1]	Adult mortality[2]	Counterfactual metric (after 35 years)		Source (MacArthur Green 2018)
			Population size (CPS)	Median growth rate (CPGR)	
Density independent	30% displacement and 1% mortality (128)	100	0.980	0.999	Tables A2_11.1, A2_11.3
		150	0.960	0.998	
	50% displacement and 1% mortality (214)	200	0.921	0.998	
		250	0.903	0.997	
	70% displacement and 1% mortality (299)	300	0.884	0.996	
	70% displacement and 10% mortality (2994)	>1600	<0.500	<0.980	
Density dependent	30% displacement and 1% mortality	100	0.981	1.000	Tables A2_12.1, A2_12.3
		150	0.972	0.999	
	50% displacement and 1% mortality	200	0.962	0.999	
		250	0.953	0.999	
	70% displacement and 1% mortality	300	0.944	0.999	
	70% displacement and 10% mortality	>1600	<0.700	<0.990	

Notes

1. Outputs are presented for the lower and upper range of potential displacement effects (in terms of the displacement and mortality rates considered), as well as for the evidence-based scenario 50% displacement and 1% mortality, and 70% displacement and 1% mortality.

2. Mortality values are used which encompass, and are closest to, the values predicted for each displacement scenario.

1373. It is also the case that the CPS and CPGR metrics described above derive from a density independent population model, which assumes no population regulation (and, as such, is biologically implausible). As a consequence, the resulting PVA is likely to give overly precautionary outputs because it does not allow for the operation of compensatory density dependence to offset (to some degree at least) the additional mortality from displacement (e.g. Horswill *et al.*

2016). Outputs from a PVA based on a density dependent (but otherwise equivalent) population model give higher CPS and CPGR values (for equivalent displacement scenarios) indicating the potentially high levels of precaution that may result from relying solely on density independent population models in the assessment. For example, for the evidence-based displacement rate of 0.500 and a mortality rate for displaced birds of 1%, the equivalent PVA outputs from the density dependent population model used in MacArthur Green (2018) predict that the population size would be just 4 – 5% smaller after 35 years than it would be under baseline conditions (Table 7.22).

1374. Given the above, it is concluded that the potential mortality of guillemot due to operational phase displacement at North Falls in-combination with other OWFs would not result in an adverse effect on the integrity of the Flamborough and Filey Coast SPA.

7.4.3.3 Razorbill

1375. This species has been screened in for appropriate assessment in relation to operational displacement / barrier effect during the breeding, migration and wintering seasons.

7.4.3.3.1 Status

1376. The Flamborough and Filey Coast SPA breeding razorbill population was cited as 10,570 pairs (or 21,140 breeding adults) for the period 2008-2011. This was based on the mean count of individuals on land of 15,776, multiplied by a correction factor (0.67) to account for birds away from the colony (Natural England 2014). A whole-colony count for the SPA in 2017 reported 20,253 pairs (or 40,506 breeding adults) (Aitken et al. 2017). The most recent whole-colony count in 2022 found 30,673 pairs (or 61,345 breeding adults) (Clarkson et al. 2022). The population trend from field counts shows an average annual increase of 6% per year since 1987, and a 230% increase since 2000 (Clarkson et al. 2022). SACOs (Natural England 2020) set a target to maintain the size of the breeding population at a level which is above 10,570 breeding pairs. whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.

7.4.3.3.2 Connectivity and Seasonal Apportionment of Potential Effects

Breeding season

1377. North Falls is 266km from the Flamborough and Filey Coast SPA boundary at the nearest point. Across all individual tracking studies of breeding adults, in the latest review of such studies by Woodward et al. (2019), the MMFR of razorbill is estimated as 88.7km (± 75.9 km SD, and the maximum foraging range is 313km (Woodward et al. 2019). Excluding data from breeding razorbill at Fair Isle where reduced prey availability was considered to have significantly increased foraging ranges during the breeding seasons in which tracking was undertaken, the MMFR is 73.8km (± 48.4km SD) and the maximum is 191 km (Woodward et al. 2019). Natural England has indicated that it is reasonable to exclude the extreme Fair Isle values when considering the potential breeding season foraging range for the Flamborough and Filey Coast SPA razorbill population (Natural England 2022b). The MMFR of razorbill in the previous review of seabird foraging ranges (Thaxter et al. 2012) was 48.5 km (±35.0km SD) based on data from four sites. The more recent review, based on 16 sites, therefore estimates a larger MMFR (Woodward et al. 2019).

1378. North Falls is therefore beyond the MMFR + 1 SD of razorbill from the Flamborough and Filey Coast SPA. On this basis, no effect is expected to occur on the SPA population in the breeding season.

1379. Modelled at-sea distributions of breeding adults, from tracking data collected during the breeding season from foraging breeding adult individuals (Cleasby et al. 2018, 2020; Wakefield et al. 2017), also suggest that North Falls is outside the home foraging range (i.e., beyond the 95% utilisation distribution) of razorbill from the Flamborough and Filey Coast SPA. On this basis, while there is a possibility of individual breeding adult razorbill being present within the North Falls footprint during the breeding season, the modelling strongly suggests that the vast majority of razorbill recorded at the North Falls footprint during the breeding season are unlikely to be breeding adults from Flamborough and Filey Coast SPA.

1380. North Falls is not within foraging range of breeding razorbill from any other SPA (or indeed non-SPA) colonies (Mitchell et al. 2004). Therefore based on the above foraging range data and utilization distribution modelling, it is likely that birds recorded at North Falls during the breeding season are non-breeding adults or sub-adult birds which have not yet reached breeding age. This may include birds from Flamborough and Filey Coast SPA and other breeding colonies.

Autumn migration season

1381. Outside the breeding season, breeding razorbills from the SPA are assumed to range widely and to mix with razorbills of all age classes from breeding colonies in the UK and other countries. The relevant reference population to North Falls is the UK North Sea and Channel BDMPS (Furness 2015) consisting of 591,874 individuals across all age classes in migration seasons (July to October, and January to March).

1382. During migration seasons, all SPA breeding adults from Flamborough and Filey Coast are considered to be present in the UK North Sea and Channel BDMPS, based on ringing and tracking data (Furness 2015). Using the estimated SPA population of 20,002 breeding adults (from the 2008 season, Furness 2015), 3.4% (20,002 / 591,874 x 100) of the BDMPS population is estimated to derive from Flamborough and Filey Coast SPA. Assuming even mixing of birds during migration seasons, 3.4% of razorbills present at North Falls in migration seasons are considered to be breeding adults from the Flamborough and Filey Coast SPA population. This is based on the SPA breeding adult population present in the BDMPS as a proportion of the total BDMPS.

1383. The mean peak razorbill population estimate at North Falls (turbine arrays + 2km buffer, the estimated zone of influence for displacement effects) during the autumn or post-breeding migration season is 266 (95% CI 112 – 445) (PEIR Chapter 13, Table 13.16). Therefore, the estimated number of breeding adult razorbills from Flamborough and Filey Coast SPA present at North Falls during the spring migration season is 9 (95% CI 4 – 15).

Winter season

1384. In the winter season (November to December, Furness 2015), the UK North Sea and Channel waters BDMPS (Furness 2015) consists of 218,622 individuals across age classes. At this time, 30% of breeding adults from

Flamborough and Filey Coast SPA are estimated, from ringing and tracking data, to be present in the UK North Sea and Channel. Based on the 2008 estimated SPA population of 20,002 breeding adults (Furness 2015), 2.7% ((0.3 x 20002) / 218,622 x 100) of birds present in the BDMPS during winter are estimated to derive from the SPA. Assuming even mixing of birds within the BDMPS, then at North Falls in the winter season 2.7% of razorbills are considered to be breeding adults from the Flamborough and Filey Coast SPA population.

1385. The mean peak razorbill population estimate at North Falls + 2km buffer during the winter season is 2,565 (95% CI 1,507 – 3,623) (PEIR Chapter 13 Volume I, Table 13.16). Therefore, the estimated number of Flamborough and Filey Coast SPA breeding adult razorbill present at North Falls during the winter season is 69 (95% CI 41 – 98).

Spring migration season

1386. As for the Autumn migration season, 3.4% of razorbills present at North Falls in the Spring migration season are considered to be breeding adults from the Flamborough and Filey Coast SPA population.

1387. The mean peak razorbill population estimate at North Falls during the spring or return migration season is 1,860 (95% CI 700 – 3,366). Therefore the estimated number of breeding adult razorbills from Flamborough and Filey Coast SPA present at North Falls during the spring migration season is 63 (95% CI 24 – 125).

7.4.3.3.3 Effect: Displacement / barrier effect during operation

1388. For the purposes of estimating the mortality that could potentially result from displacement effects, displacement rates of 30% to 70% are considered for this species, along with a range of mortality rates of from 1% to 10% of displaced birds (UK SNCBs 2017).

1389. The upper values within those ranges are likely to be overly precautionary, both for displacement and mortality. The available evidence suggests that auks (guillemots and razorbills) tend to be displaced from OWFs, with displacement rates varying between sites but, on average, it is considered that densities within OWFs tend to be approximately half of those occurring in the habitats around the OWF (MacArthur Green 2019). Displacement may also occur from a buffer zone around the OWF although this does not usually extend as far as 2km out from the OWF. Based on consideration of the quality of, or confidence in, the studies used to derive the recommended range of displacement rates, as well as those studies demonstrating no significant displacement, APEM (2022) suggest that a displacement rate of 0.500 is appropriate for auks.

1390. Mortality as a result of displacement could occur due to increased energy expenditure and / or decreased energy intake (e.g. from increased flight time or increased intra-specific competition associated with higher densities in foraging habitat outside OWFs). However, OWFs represent a small proportion of the available foraging habitat for guillemot in the North Sea and increases in densities outside OWFs are likely to be negligible (MacArthur Green 2019). When considered within the context of a baseline annual mortality rate (i.e. in the absence of OWF effects) for adult razorbills of 10.5% (Horswill and Robinson 2015), increases due to displacement are more likely to be at the lower range of the advised rates, if not below these (MacArthur Green 2019). Thus, based on consideration of available evidence, together with what is biologically plausible, both MacArthur Green (2019) and APEM (2022) suggest that a displacement rate of 0.500 and mortality rate amongst displaced birds of 1% are sufficiently precautionary.

1391. A more detailed review of the evidence in relation to displacement of auks from OWFs is included in PEIR Chapter 13 Volume I, Section 13.6.2.1.2.1.

1392. In the absence of OWF effects, the baseline mortality of the Flamborough and Filey Coast SPA breeding adult population of razorbill is estimated to be 6,441 individuals per year, based on a population of 61,345 breeding adults (Clarkson et al. 2022) and an annual adult mortality rate of 0.105 (1 – survival rate from Horswill and Robinson 2015, PEIR Chapter 13 Volume, Table 13.13).

7.4.3.3.4 Project alone assessment

1393. Based on the seasonal mean peak abundances, the estimated total number of SPA breeding adult razorbills present at North Falls throughout the year and potentially subject to displacement by the project alone is 142 (95% CI 68 – 238).

1394. At displacement rates of 30% to 70% and mortality rates of 1% to 10% for displaced birds, 0 to 10 SPA breeding adults would be predicted to die each year due to displacement from North Falls (95% LCI 0 to 5 breeding adults, 95% UCI 1 to 17 breeding adults) (**Table** 7.23).

1395. This would increase annual mortality within the Flamborough and Filey Coast SPA breeding adult population by 0% to 0.2% (95% LCI 0% to 0.1%; 95% UCI 0% to 0.3%) (Table 7.24). Using an evidence-based displacement rate of 0.500 and a mortality rate for displaced birds of 1%, annual mortality in the Flamborough and Filey Coast SPA breeding adult razorbill population would increase by 0% due to displacement from North Falls alone (95% CI 0% - 0%).

1396. Increases in the existing mortality rate of less than 1% are likely to be undetectable against natural variation. This means that no detectable changes in mortality rates would occur under any combination of displacement and mortality rates when the mean peak abundance estimate assessments are considered.

1397. It is concluded that predicted razorbill mortality due to operational phase displacement at North Falls alone would not adversely affect the integrity of the Flamborough and Filey Coast SPA.

Table 7.23 Displacement matrix for razorbill for the project alone. The cells show the number of predicted bird mortalities (to the nearest integer) per annum at given rates of displacement and mortality (LCI and UCI = upper and lower 95% confidence intervals). Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean	Mortality										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	1	1	1	3	4	7	11	14
20%	0	1	1	1	1	3	6	9	14	23	28
30%	0	1	1	2	2	4	9	13	21	34	43
40%	1	1	2	2	3	6	11	17	28	45	57
50%	1	1	2	3	4	7	14	21	36	57	71
60%	1	2	3	3	4	9	17	26	43	68	85
70%	1	2	3	4	5	10	20	30	50	80	99
80%	1	2	3	5	6	11	23	34	57	91	114
90%	1	3	4	5	6	13	26	38	64	102	128
100%	1	3	4	6	7	14	28	43	71	114	142

LCI	Mortality										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	1	1	2	3	5	7
20%	0	0	0	1	1	1	3	4	7	11	14
30%	0	0	1	1	1	2	4	6	10	16	20
40%	0	1	1	1	1	3	5	8	14	22	27
50%	0	1	1	1	2	3	7	10	17	27	34
60%	0	1	1	2	2	4	8	12	20	33	41
70%	0	1	1	2	2	5	10	14	24	38	48
80%	1	1	2	2	3	5	11	16	27	44	55
90%	1	1	2	2	3	6	12	18	31	49	61
100%	1	1	2	3	3	7	14	20	34	55	68

UCI	Mortality										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	1	1	1	2	5	7	12	19	24
20%	0	1	1	2	2	5	10	14	24	38	48
30%	1	1	2	3	4	7	14	21	36	57	71
40%	1	2	3	4	5	10	19	29	48	76	95
50%	1	2	4	5	6	12	24	36	59	95	119
60%	1	3	4	6	7	14	29	43	71	114	143
70%	2	3	5	7	8	17	33	50	83	133	166
80%	2	4	6	8	10	19	38	57	95	152	190
90%	2	4	6	9	11	21	43	64	107	171	214
100%	2	5	7	10	12	24	48	71	119	190	238

Table 7.24 Displacement matrix for razorbill for the project alone. The cells show the % increase in the mortality rate of the SPA population associated with the number of predicted bird mortalities (to the nearest integer) per annum at given rates of displacement and mortality given in Table 7.23. (LCI and UCI = upper and lower 95% confidence intervals). Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean	Mortality										
Displacement		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
	10%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%
	20%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.4%
	30%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.7%
	40%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.4%	0.7%	0.9%
	50%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.6%	0.9%	1.1%
	60%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.3%	0.4%	0.7%	1.1%	1.3%
	70%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.8%	1.2%	1.5%
	80%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.5%	0.9%	1.4%	1.8%
	90%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.6%	1.0%	1.6%	2.0%
	100%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.7%	1.1%	1.8%	2.2%
LCI	**Mortality**											
Displacement		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
	10%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
	20%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%
	30%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.3%
	40%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
	50%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%	0.5%
	60%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.6%
	70%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.6%	0.7%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.4%	0.7%	0.8%
	90%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.5%	0.8%	1.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.8%	1.1%
UCI	**Mortality**											
Displacement		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
	10%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.4%
	20%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.4%	0.6%	0.7%
	30%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.3%	0.6%	0.9%	1.1%
	40%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.3%	0.4%	0.7%	1.2%	1.5%
	50%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.6%	0.9%	1.5%	1.8%
	60%	0.0%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.7%	1.1%	1.8%	2.2%
	70%	0.0%	0.1%	0.1%	0.1%	0.1%	0.3%	0.5%	0.8%	1.3%	2.1%	2.6%
	80%	0.0%	0.1%	0.1%	0.1%	0.1%	0.3%	0.6%	0.9%	1.5%	2.4%	3.0%
	90%	0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.7%	1.0%	1.7%	2.7%	3.3%
	100%	0.0%	0.1%	0.1%	0.1%	0.2%	0.4%	0.7%	1.1%	1.8%	3.0%	3.7%

1398. The confidence in the assessment is high for several reasons. Firstly, the evidence used to inform the displacement rates is of high applicability and quality. Also, whilst there is limited available evidence to inform mortality rates, 1% is considered to be sufficiently precautionary based consideration of the plausible extent of such effects within the context of the species biology. Notably, this species is not regarded as being highly specialised in its habitat requirements (Bradbury et al. 2014; Furness & Wade 2012; Garthe & Hüppop 2004), and it is therefore anticipated that displaced birds will find alternative habitat in the vast majority of cases. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI mean peak abundances are used to calculate potential mortality and consequent increases in baseline mortality rate of the SPA adult population (even when the overly precautionary rates of 70% displacement and 10% mortality are applied).

7.4.3.3.5 In combination assessment

1399. Seasonal and annual population estimates of breeding adult razorbill at all OWFs included in the in-combination assessment are presented in Table 7.25 along with the numbers apportioned to the Flamborough and Filey Coast SPA This information was taken from the latest numbers presented at Deadline 11 of the DCO Examination for East Anglia ONE North and East Anglia TWO projects (MacArthur Green and Royal HaskoningDHV 2021c), but updated with new information that has become available since then for some OWFs (see Table 7.25).

1400. The estimated annual total of breeding adult razorbill from Flamborough and Filey Coast SPA at risk of displacement from all OWFs within the UK North Sea BDMPS combined is 10,392 (Table 7.25). Of this total, North Falls contributes 142 (1.4%). Using displacement rates of 30% to 70% and mortality rates of 1% to 10% of displaced birds (UK SNCBs 2017), the number of Flamborough and Filey Coast SPA adults predicted to die each year as a result of projects in-combination would be between 31 and 727 (Table 7.26).

1401. The estimated increase in mortality of Flamborough and Filey Coast SPA breeding adult razorbill due to in-combination displacement impacts is between 0.5% and 11.3% (Table 7.27). Using an evidence-based displacement rate of 50% and a mortality rate for displaced birds of 1%, annual mortality in the Flamborough and Filey Coast SPA breeding adult razorbill population would increase by 0.8% due to in-combination impacts from all OWFs. Considering 70% displacement and 1% mortality, the predicted increase in the SPA population mortality rate would be 1.1%. Increases in the existing mortality rate of greater than 1% could be detectable against natural variation.

1402. PVA outputs are used to further assess the potential population level impact. For the purposes of the North Falls PEIR, the PVAs for the Flamborough and Filey Coast SPA guillemot population which were produced to inform the Hornsea Project Three OWF are used (MacArthur Green 2018). It is proposed to update these with PVAs specific to the North Falls project, subsequent to the PEIR.

Table 7.25 Seasonal and annual population estimates of razorbills at North Falls and other OWFs included in the in-combination assessment; and apportionment (breeding adult birds) to the Flamborough and Filey Coast SPA

Tier	OWF	Seasonal Population At Risk Of Displacement[1]									
		Breeding		Autumn Migration		Non-Breeding		Spring Migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Beatrice Demonstrator	No estimate available									
1	Beatrice	873	0	833	28	555		833	28	3094	72
1	Blyth Demonstration	121	121	91	3	61	2	91	3	364	129
1	Dudgeon	256	0	346	12	745	20	346	12	1694	44
1	East Anglia ONE	16	0	26	1	155	4	336	11	533	16
1	EOWDC (Aberdeen)	161	0	64	2	7	0	26	1	258	3
1	GWF	44	0	43	1	106	3	394	13	587	18
1	GGOW	0	0	0	0	387	10	84	3	471	13
1	Gunfleet Sands	0	0	0	0	30	1	0	0	30	1
1	Hornsea Project One	1109	535	4812	164	1518	41	1803	61	9242	800
1	Hornsea Project Two	2511	1210	4221	143	720	19	1668	57	9119	1430
1	Humber Gateway	27	27	20	1	13	0	20	1	80	29
1	Hywind	30	0	719	24	10	0	0	0	759	25
1	Kentish Flats and Extension	No estimate available									
1	Kincardine	22	0	0	0	0	0	0	0	22	0
1	Lincs, Lynn and Inner Dowsing	45	45	34	1	22	1	34	1	134	48
1	London Array	14	0	20	1	14	0	20	1	68	2
1	Moray Firth East	2423	0	1103	37	30	1	168	6	3724	44
1	Race Bank	28	28	42	1	28	1	42	1	140	32
1	Rampion	630	0	66	2	1244	34	3327	113	5267	149
1	Scroby Sands	No estimate available									

Tier	OWF	Seasonal Population At Risk Of Displacement[1]									
		Breeding		Autumn Migration		Non-Breeding		Spring Migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
1	Sheringham Shoal	106	0	1343	46	211	6	30	1	1691	52
1	Teesside	16	0	62	2	2	0	20	1	99	19
1	Thanet	3	16	0	0	14	0	21	1	38	1
1	Triton Knoll	40	0	254	9	855	23	117	4	1265	76
1	Westermost Rough	91	40	121	4	152	4	91	3	455	102
2	Dogger Bank (formerly Creyke Beck) A and B	2788	91	3673	125	3871	105	9268	315	19600	1381
2	Dogger Bank C (formerly Teesside A) and Sofia (formerly Teesside B)	1987	836	903	31	2385	64	4872	166	10146	857
2	Firth of Forth (Seagreen) Alpha and Bravo	9574	596	891	30	594	16	891	30	11950	77
2	Moray West	2808	0	3544	120	184	5	3585	122	10121	247
2	Neart na Gaoithe	331	0	5492	187	508	14			6331	200
3	East Anglia ONE North	403	0	85	3	54	1	207	7	749	11
3	East Anglia THREE	1807	0	1122	38	1499	40	1524	52	5952	130
3	East Anglia TWO	281	0	44	1	136	4	230	8	691	13
3	Hornsea Project Three[2]	630	0	2020	69	3649	99	2105	72	8404	239
3	Inch Cape	1436	0	2870	98	651	18			4957	115
3	Methil	4	0	0	0	0	0	0	0	4	0
3	Norfolk Boreas	630	0	263	9	1065	29	345	12	2303	49
3	Norfolk Vanguard	879	0	866	29	839	23	924	31	3508	84
Total (tier 1-3 projects)		32,124	3,545	35,992	1,224	22,313	602	33,421	1,136	123,850	6,508
4	Hornsea Project Four[3]	386	386	4311	2845	455	12	449	15	5601	3258

Tier	OWF	Seasonal Population At Risk Of Displacement[1]									
		Breeding		Autumn Migration		Non-Breeding		Spring Migration		Annual	
		Total	FFC	Total	FFC	Total	FFC	Total	FFC	Total	FFC
4	DEP (RIAA)[4]	3741	258	923	31	845	23	320	11	5829	3806
4	SEP (RIAA)[4]	759	52	316	11	686	19	144	5	1905	793
5	Rampion 2[5]	44	0	19	1	22	1	2164	74	2249	75
5	North Falls	168	0	266	9	2565	726	1860	1304	4859	142
Total (all projects)		37,222	4,242	41,827	4,121	26,886	726	38,358	1304	144,293	10,392

Notes:

The preferred standard area is the OWF plus a 2km buffer, however the buffer zones included in this assessment varied between 0-4km depending on the data available. Project total and Flamborough and Filey Coast estimates follow those of East Anglia ONE North/East Anglia TWO Deadline 11 Offshore Ornithology Cumulative and In-Combination Collision Risk and Displacement Update, except where footnoted.

Source: the East Anglia ONE N/East Anglia TWO Deadline 11 Offshore Ornithology Cumulative and In-Combination Collision Risk and Displacement Update (MacArthur Green and Royal HaskoningDHV 2021c) and Hornsea Project 4 Deadline 6 (APEM and Gobe 2022) revised totals for Hornsea Project Three identify 64% of the guillemots present during the breeding season as being apportioned to the Flamborough and Filey Coast SPA (i.e. 8,502 birds). However, given Hornsea Three is approximately 149km from the SPA, the apportionment undertaken for the project determined that adult razorbills from the SPA were not present on the project array area during the breeding season and the apportionment value of 64% refers instead to immature birds from the SPA (see NIRAS 2019, 2021). As such, the above totals apportioned to the SPA do not include adult birds from Hornsea Three during the breeding season.

Source: Hornsea Project 4 Deadline 6 Ornithology EIA and HRA Annex, Deadline 6 (This is based on the Natural England requested approach that during the post-breeding migration period (considered to be the chick-rearing / moult period) 66% of razorbills at Hornsea 4 are apportioned to Flamborough and Filey Coast SPA).

Source: DEP SEP RIAA and Examination Submission 13.3 with apportioning updates.

Source: Rampion PEIR

Table 7.26 In combination displacement matrix for razorbill. The cells show the number of predicted bird mortalities (to the nearest integer) per annum at given rates of displacement and mortality. Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean Displacement	Mortality										
	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	10	21	31	42	52	104	208	312	520	831	1039
20%	19	37	56	75	94	187	374	561	935	1497	1871
30%	31	62	94	125	156	312	624	935	1559	2494	3118
40%	42	83	125	166	208	416	831	1247	2078	3326	4157
50%	52	104	156	208	260	520	1039	1559	2598	4157	5196
60%	62	125	187	249	312	624	1247	1871	3118	4988	6235
70%	73	145	218	291	364	727	1455	2182	3637	5820	7275
80%	83	166	249	333	416	831	1663	2494	4157	6651	8314
90%	94	187	281	374	468	935	1871	2806	4677	7483	9353
100%	104	208	312	416	520	1039	2078	3118	5196	8314	10392

Table 7.27 In combination displacement matrix for razorbill. The cells show the % increase in the mortality rate of the SPA population associated with the number of predicted bird mortalities per annum at given rates of displacement and mortality given in Table 7.27. Grey cells identify the range of displacement and mortality rates considered in the assessment.

Mean Displacement	Mortality										
	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0.2%	0.3%	0.5%	0.6%	0.8%	1.6%	3.2%	4.8%	8.1%	12.9%	16.1%
20%	0.3%	0.6%	0.9%	1.2%	1.5%	2.9%	5.8%	8.7%	14.5%	23.2%	29.0%
30%	0.5%	1.0%	1.5%	1.9%	2.4%	4.8%	9.7%	14.5%	24.2%	38.7%	48.4%
40%	0.6%	1.3%	1.9%	2.6%	3.2%	6.5%	12.9%	19.4%	32.3%	51.6%	64.5%
50%	0.8%	1.6%	2.4%	3.2%	4.0%	8.1%	16.1%	24.2%	40.3%	64.5%	80.7%
60%	1.0%	1.9%	2.9%	3.9%	4.8%	9.7%	19.4%	29.0%	48.4%	77.4%	96.8%
70%	1.1%	2.3%	3.4%	4.5%	5.6%	11.3%	22.6%	33.9%	56.5%	90.4%	112.9%
80%	1.3%	2.6%	3.9%	5.2%	6.5%	12.9%	25.8%	38.7%	64.5%	103.3%	129.1%
90%	1.5%	2.9%	4.4%	5.8%	7.3%	14.5%	29.0%	43.6%	72.6%	116.2%	145.2%
100%	1.6%	3.2%	4.8%	6.5%	8.1%	16.1%	32.3%	48.4%	80.7%	129.1%	161.3%

1403. A number of different PVAs for the SPA guillemot population were produced for the Hornsea Project Three OWF, with each of these considering the potential effects of additional adult mortality over a 35-year period, with the additional mortality applied in increments of 50 birds up to a maximum of 1000. Outputs included the two key metrics which are recommended for use in interpreting PVAs on the basis that they have relatively low sensitivity to factors such as varying population status and the mis-specification of the demographic rates underpinning the population model (Cook and Robinson 2015, Jitlal et al., 2017). These metrics are:

- The CPS - the median of the ratio of the end-point size of the impacted to un-impacted (or baseline) population, expressed as a proportion; and
- The CPGR - the median of the ratio of the annual growth rate of the impacted to un-impacted population, expressed as a proportion.

1404. The current assessment focusses on the outputs from the PVA which is based upon a density independent population model, using demographic rates as specified in Horswill and Robinson (2015) (i.e demographic rate set 2 in MacArthur Green 2018) and which was undertaken using a matched runs approach. The key outputs from this PVA are found in Table 7.28.

1405. On the basis of this PVA, the additional in-combination mortality predicted to result from the evidence-based displacement rate of 0.500 and a mortality rate for displaced birds of 1% (i.e. 52 adult birds per annum) gives CPS and CPGR values of approximately 0.923 and 0.998, respectively (Table 7.28). Therefore, for this scenario, the potential in-combination mortality is predicted to result in a population size which is about 8% smaller after 35 years than it would be under baseline conditions (i.e. without the additional mortality from displacement). Such a potential reduction in population size is considered to represent a small level of impact, and is highly unlikely to prevent achievement of the target to maintain the size of the breeding population above the SPA citation level. whilst avoiding deterioration from its current level (as set out within the SACOs for this SPA). This is particularly the case, given that this potential level of impact is within the context of a long-term, and consistently, increasing trend in the size of the SPA population.

1406. Clearly, higher rates of displacement and mortality result in greater levels of predicted impacts and at the upper range of the advised rates (i.e. 70% displacement and 10% mortality of displaced birds), the CPS and CPGR values are markedly lower and represent a substantive potential impact. However, these higher displacement rates are not supported by the available evidence, whilst such high levels of mortality are not considered to be plausible. Thus, it is considered that levels of displacement and mortality sufficient to prevent achievement of the target to maintain the size of the breeding population above the citation level, whilst avoiding deterioration from its current level, would not occur.

1407. It is also the case that the CPS and CPGR metrics described above derive from a density independent population model, which assumes no population regulation (and, as such, is biologically implausible). As a consequence, the resulting PVA is likely to give overly precautionary outputs because it does not allow for the operation of compensatory density dependence to offset (to some degree at least) the additional mortality from displacement (e.g. Horswill et al. 2016). Outputs from a PVA based on a density dependent (but otherwise equivalent) population model give higher CPS and CPGR values (for equivalent displacement scenarios) indicating the potentially high levels of precaution that may result from relying solely on density independent population models in the assessment. For example, for the evidence-based displacement rate of 50% and a mortality rate for displaced birds of 1%, the equivalent PVA outputs from the density dependent population model used in MacArthur Green (2018) predict that the population size would be about 6% smaller after 35 years than it would be under baseline conditions (Table 7.28).

Table 7.28 Values for Counterfactual Metrics Summarising Outputs from Population Viability Analyses for the Flamborough and Filey Coast SPA razorbill population in relation to the potential in-combination mortality due to displacement from OWFs

Model	Scenario[1]	Adult mortality[2]	Counterfactual metric (after 35 years) Population size (CPS)	Median growth rate (CPGR)	Source table (MacArthur Green 2018)
Density independent	30% displacement, 1% mortality (31), 50% displacement, 1% mortality (52)	50	0.923	0.998	A2_15.1, A2_15.3
	70% displacement, 1% mortality (73)	100	0.851	0.995	
	70% displacement, 10% mortality (727)	750	0.292	0.964	
Density dependent	30% displacement, 1% mortality (31), 50% displacement, 1% mortality (52)	50	0.942	0.998	A2_16.1, A2_16.3
	70% displacement, 1% mortality (73)	100	0.886	0.997	
	70% displacement, 10% mortality (727)	750	0.357	0.971	

1. Outputs are presented for the lower and upper range of displacement (30-70%) at 1% mortality, the evidence-based 50% displacement and 1% mortality, 70% displacement and 1% mortality, and the worst case 70% displacement and 10% mortality (numbers in brackets give the predicted mortality under each scenario).

2. Mortality values modelled in the PVA are used which encompass, and are closest to, the values predicted for each displacement scenario.

1408. It is concluded that the potential mortality of razorbill due to operational phase displacement at North Falls in-combination with other OWFs would not result in an adverse effect on the integrity of the Flamborough and Filey Coast SPA.

8 Onshore ornithology (SPAs and Ramsar sites)

8.1 Approach to assessment

1409. This section provides information to determine whether an AEoI of any onshore SPAs or Ramsar sites may result due to impacts of the project on ornithological qualifying features.

1410. The assessment is based on the onshore project description in Section 3. It should be read in conjunction with:

- North Falls HRA Screening Report (Appendix 1);
- PEIR Chapter 24 Onshore Ornithology (Volume I); and
- PEIR Onshore Ornithology Appendices 24.1 to 24.4 (Volume III).

8.1.1 Consultation

1411. The onshore HRA Screening Report was submitted to the relevant ETGs on 2nd November 2022 and discussed in an ETG meeting on 15 November 2022. The following stakeholders were consulted as part of the ETG:

- Natural England;
- RSPB;
- Essex Wildlife Trust;
- Essex County Council;
- Tendring District Council; and
- Environment Agency.

1412. The consultation responses relevant to the RIAA which have been received to date are summarised in Table 8.1.

Table 8.1 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
Tendring District Council (Places Services)	15/11/2023 Onshore Ecology and Ornithology Expert Topic Group Meeting 2	If any of the Site of Special Scientific Interest (SSSI) features which underpin the qualifying features of European sites were identified as potentially subject to effects during construction or operation of the project, and therefore potentially giving rise to LSE upon the qualifying features, this will need to be taken into account during the HRA screening.	Features which support European sites have been considered in both the screening and in this RIAA.
Natural England	02/12/2022 Comments on HRA Screening Report	We note that North Falls has chosen an area of 10km for the desk-based study area for designated sites, and the rationale for this buffer should be provided. However, we advise that the scoping area should be based on the potential for species to be present within the area, the Impact Risk Zone (IRZ) for designated sites as available on Magic, the ecology, i.e. foraging areas of designated species of sites in proximity to the proposed development area, and consideration given to Functionally Linked Land. We repeat our earlier advice, that the onus is on the Applicant to determine whether there is sufficient information/evidence to exclude areas from the desk-based study and for surveys.	NFOW are comfortable that the 10km buffer used for the initial 'sift' of sites for consideration within the HRA screening is the right buffer to use – this has been selected as the largest buffer from the various buffers used when considering different potential indirect effects (see Table 9-1). The largest buffer relates to effects upon ex-situ habitats, and here the 10km buffer has been used based on existing literature which identifies that potential foraging ranges of up to 10km for typical geese and wader species of the east of England can commonly occur from core feeding grounds (Hearn, 2004; Gillings and Fuller, 1999). NFOW notes that SSSI IRZs for the SSSI which underpin the European & Ramsar sites considered in the HRA Screening extend at most to 5km, so all are covered by using this 10km buffer for the initial sift. Please note a further, more detailed sift of potential likely significant effects requiring further consideration in the Appropriate Assessment which considers different buffers for different indirect effects described in Table 9-1, is set out in Table 9-4 of the HRA Screening Report (Appendix 1).
Natural England	10/02/2023 Further comments on	*[Response to NFOW comments]* We are content with the sites that have been scoped into the assessment, however, we advise that the Project should be mindful	Sites screened in detailed in HRA Screening Report (Appendix 1) and summarised in Section 4.5.

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
	HRA Screening Report	of the IRZs, foraging areas of designated species, and functionally linked land (FLL) on a site-by-site basis.	
Natural England	02/12/2022 Comments on HRA Screening Report	5.2 Potential Effects Considered in Screening: Section 9.3, Table 9-3 - Direct temporary damage / disruption of habitats within site boundaries which support qualifying features. This has not been included for the Construction, Operation or Decommissioning stages. Whilst impacts to ex-situ habitats have been considered, suitable habitats at the site that may support the qualifying features of the SPA have not been considered. Habitats within the project area could potentially support qualifying features of the protected sites, e.g. dark-bellied brent geese (Hamford Water SPA 0.3km and Stour and Orwell Estuaries SPA 3.3km).	Direct effects here is being used to refer to those effects which occur on upon habitats which occur within the European site boundary. As the project's onshore project area has been routed to avoided European designations / Ramsar sites, then no direct effects under this definition can occur. Separately, potential effects upon ex-situ habitats located outside the European site boundary but within the onshore project area up to 10km from the European site have been screened in for further assessment within the Appropriate Assessment – see Table 9-3, Row 7. Hopefully this clarifies that ex-situ habitats are proposed to be considered further.
Natural England	10/02/2023 Further comments on HRA Screening Report	*[Response to NFOW comments]* We are content with the information and explanation provided. We are, therefore, content with the proposed screening for direct temporary damage/disruption of habitats within site boundaries which support qualifying features.	Noted.
Natural England	02/12/2022 Comments on HRA Screening Report	5.3 Section 9.4 Screening: Pages 172-177, Table 9-4 Onshore Ornithology - Screening Summary Potential for a Direct temporary effect to habitats within the project area that support the qualifying features of the sites listed in the table (Hamford Water SPA and Ramsar, Stour and Orwell Estuaries SPA and Ramsar, Colne Estuary (Mid-Essex Coast Phase 2) SPA and Ramsar) need to be included as per the above comment.	See above comment.
Natural England	10/02/2023 Further comments on HRA	*[Response to NFOW comments]* We are also content with this screening.	Noted.

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
	Screening Report		
Natural England	02/12/2022 Comments on HRA Screening Report	We also advise that the project should fully consider cumulative impacts for the different construction scenarios with Five Estuaries e.g. concurrently, sequentially etc., as was discussed in the ETG.	NFOW agree, and have considered the Five Estuaries project within the in-combination assessment, using the most up-to-date information shared with NFOW by the project at the time of writing.
Natural England	02/12/2022 Comments on HRA Screening Report	Water Quality and Quantity - Depending on the final red line boundary and infrastructure area it may be necessary to consider potential impacts to water tables and water quality and quantity in relation to designated sites and features within the water catchments.	NFOW agree, and this has been considered within the screening and within this draft RIAA, with such potential effects upon Hamford Water screened in for further assessment.

8.1.2 Worst case scenario

1413. The worst-case scenarios for construction, operation and decommissioning related to the onshore project area are presented in Section 3. The shadow appropriate assessments for each designated site screened in (Section 4) have been based on these worst-case scenarios.

8.1.3 Embedded mitigation

1414. This section outlines the embedded mitigation relevant to the onshore ornithology assessment, which has been incorporated into the design of North Falls (Table 8.2).

Table 8.2 Embedded mitigation measures

PARAMETER	MITIGATION MEASURES EMBEDDED INTO NORTH FALLS DESIGN
All receptors	Prior to works commencing, North Falls will prepare an Ecological Management Plan (EMP) setting out full details of the ecological mitigation measures which will be adhered to during the Project's construction. This will include: • A programme of works; • A list of roles and responsibilities for ecological mitigation, including the role of an ecological clerk of works (ECoW); • A plan showing ecological constraints; • Full details of best practice mitigation required in relation to all species and habitats affected by the Project; • Full details of any project-specific mitigation identified within this chapter, including habitat creation or protected species mitigation programmes. Any such programmes will be accompanied by mitigation layout plans; • A list of protected species licences and site consents required to facilitate construction; • Habitat reinstatement method statements for all habitats proposed to be reinstated following the completion of construction (including grassland, hedgerows, watercourses and arable field margins – see below); • Any associated standalone mitigation plans, e.g. reptile precautionary method of works, invasive species management plan, etc. as required. The EMP will include details of best practice for minimising impact to notable habitats and legally protected and notable species. As part of the Project's DCO application, an Outline Landscape and Ecological Management Strategy (OLEMS) will be submitted which will set out the ecological mitigation requirements identified within the ES that must be incorporated into the EMP for delivery during the Project's construction.
All receptors (best practice)	The EMP will include details of best practice for minimising impact to notable habitats and legally protected and notable species, including (but not limited to): • Avoid undertaking vegetation removal during the bird nesting season (March – August inclusive, although weather dependent) (see Chapter 24 Onshore Ornithology, Volume I of the PEIR). Where this cannot be achieved, a pre-construction check of all nesting habitat is required no more than 48 hours prior to removal. Should a nest be found, a buffer zone (minimum 5m) around the nest must be created, and no works must be undertaken within the buffer zone until the young have fledged. This mitigation also applies to suitable habitat for ground nesting birds. • Ensuring security lighting used during construction adheres as far as possible to accepted lighting guidance (Bat Conservation Trust (BCT) and Institute of Lighting Professionals (ILP), 2018), This will include the following measures: • Ensure lighting is cowled and angled downwards and does not shine directly on sensitive habitats; • Ensure lighting is motion activated to minimise unnecessary lighting;

PARAMETER	MITIGATION MEASURES EMBEDDED INTO NORTH FALLS DESIGN
	• Ensuring best practice pollution prevention measures are adhered to at all times to minimise the risk of pollutant release to sensitive habitats (see Chapter 21 Water Resources and Flood Risk, Volume I of the PEIR). • Best Practical Means (BPM) to be employed during construction to limit dust, odour, and exhaust emissions during construction works, to reduce potential effects upon air quality-sensitive habitat (see Chapter 20 Onshore Air Quality, Volume I of the PEIR). • All habitats temporarily disturbed during constricted are reinstated in full upon completion of construction.
Mitigation by site selection	The onshore project area and onshore substation zone have been defined following an extensive site selection process, which has sought to take account of environmental, engineering, planning and land requirements to seek to identify the most sensitive project location. The site selection process is described in detail in Chapter 4 Site Selection and Assessment of Alternatives Volume I of the PEIR. The site selection process has included consideration of the following ecological criteria as part of the process: • Avoidance of European sites and associated buffer zones for indirect effects, as far as possible; • Avoidance of habitat potentially suitable for supporting legally protected and notable species as far as possible. As part of this process, the onshore project area presented in PEIR Chapter 5 Project Description (Volume I) does not overlap with a European site for nature conservation.
Mitigation by construction method selection	North Falls has committed to seeking to use trenchless techniques (e.g. HDD) where possible at all key sensitive linear features, including the following: • Selected hedgerows; • Selected watercourses; • Veteran trees; • Woodland UK Habitat of Principal Importance (UKHPI); • Ponds UKHPI. At this stage in the Project's design, trenchless techniques cannot be committed to at all locations, where the engineering feasibility of using such techniques needs further assessment before it can be confirmed. The list of techniques being considered at each crossing is described in PEIR Chapter 5 Project Description (Volume I), Appendix 5.1 Crossing Schedule (Volume III).
	At all trenched watercourse crossings, best practice measures will be in place to minimise disturbance of the beds, banks and downstream habitats (see PEIR Chapter 21 Water Resources and Flood Risk, Volume I): The amount of time that any temporary dams are in place will be kept to a minimum; Prior to dewatering the area between any temporary dams, a fish rescue would be undertaken; Flumes or pumps would be adequately sized to ensure that flows downstream are maintained whilst minimising upstream impoundment; Scour protection would also be used to protect the river bed downstream of the dam from high energy flow at the outlets of flumes and pumps; and Sympathetic reinstatement of channel and banks.
HDD	As advised by Natural England during the EPP, an Outline HDD Method and Draft 'Break-out' Contingency Plan will be submitted with the Project's DCO application to provide assurance that reasonable steps will be taken to minimise the risk of effects arising as a result of 'break-out' during HDD beneath watercourses.
Habitat reinstatement	As noted above, where practicable, all habitats subject to temporary disturbance during construction, will be reinstated in full following the completion of construction. The specific details of the reinstatement will be set out within the EMP for each habitat. The following core principles for habitat reinstatement would be included within the EMP relevant to the RIAA: Grassland habitats All topsoil stripped in grassland areas would be stored separately and reinstated following the completion of construction. Topsoil storage would be subject to a Soil Management Plan, which would also detail measures for soil storage and handling.

PARAMETER	MITIGATION MEASURES EMBEDDED INTO NORTH FALLS DESIGN
	Grassland reseeding would be undertaken using a local seed mix, to be agreed in advance with Natural England and Essex Wildlife Trust. Trees and hedgerows As advised by Essex County Council during the Evidenve Plan Process (EPP), all tree and shrub planting undertaken by NFOW will be subject to an up to 10 year after care period. As advised by Natural England during the EPP, all hedgerows within the onshore project area not removed for construction to be allowed, where practicable, to thicken up during construction and operation to facilitate use as feeding and commuting corridors for wildlife. Arable field margins If landowner permission can be reached, this habitat will be reinstated in consultation with Essex Wildlife Trust and the local landowner to ensure the optimum benefits can be gained from each margin affected. Prior to construction, the arable field margins will be re-surveyed to assess their conservation value. Attempts will then be made to ensure habitat reinstatement takes the form of one of the following (JNCC, 2008): Cultivated, low-input margins (land managed specifically to create habitat for annual arable plants); Margins sown to provide seed for wild birds (margins or blocks sown with plants that are allowed to set seed and which remain in place over the winter); Margins sown with wild flowers or agricultural legumes and managed to allow flowering to provide pollen and nectar resources for invertebrates; Margins providing permanent, grass strips with mixtures of tussocky and fine-leaved grasses.

8.1.4 Scope of the shadow Appropriate Assessment

1415. The shadow Appropriate Assessment considers the following effects, based on those identified in the HRA Screening Report (Appendix 1):

- Direct habitat loss to ex-situ habitats which support qualifying features.
- Indirect disturbance of qualifying features from noise and visual disturbance (in-situ and ex-situ);
- Indirect impacts on habitats which support qualifying features from air quality emissions and changes in supporting surface or groundwater resources.

1416. With respect to each of these effects, a shadow Appropriate Assessment is carried out for each designated site's qualifying features, within the context of the site's conservation objectives. The assessment should be read in conjunction with PEIR Chapter 24 Onshore Ornithology and PEIR Appendices 24.1 to 24.4 (Volume III) which present detailed information on baseline conditions within the onshore project area, and an assessment on impacts to Important Ornithological Features, including some species which are also qualifying features of SPAs and Ramsar sites, as well as on Sites of Special Scientific Interest (SSSIs) which overlap with the extent of the SPA and Ramsar sites and often share qualifying features.

8.1.5 Conservation objectives

1417. The conservation objectives for all assessed SPAs have been determined by Natural England (2019) as follows:

1418. Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

- The extent and distribution of the habitats of the qualifying features;
- The structure and function of the habitats of the qualifying features;
- The supporting processes on which the habitats of the qualifying features rely;
- The population of each of the qualifying features, and,
- The distribution of the qualifying features within the site.

1419. These conservation objectives are considered in the process of determining AEoI of SPAs (and by extension, Ramsar sites), whereupon evidence is provided to ascertain which, and whether any of the SPA's conservation objectives may be compromised due to a predicted impact.

8.2 Hamford Water SPA and Ramsar site

8.2.1 Site overview

1420. A list of qualifying features for the Hamford Water SPA and Ramsar site are presented in Table 4.3, and cited and current SPA populations are given in Table 8.3. Most are qualifying features of both designated sites, although the Ramsar site citation does not include breeding little tern and non-breeding avocet and shelduck. The SPA and Ramsar site are similar in extent (excluding the marine component of the SPA) and because impacts are likely to be similar, the conclusions of the assessment of effects on the integrity of the SPA are also applicable to the Ramsar site, unless specifically noted.

1421. Hamford Water SPA is approximately 300m from the onshore project area at its closest point (see Figure 24.1 (Volume II)). It is a large tidal embayment between Walton-on-the-Naze and Dovercourt on the north Essex coastline in eastern England. The site is a large, shallow basin, protected by The Naze headland, which supports a wide range of habitats, including tidal creeks, mud and sand flats, grasslands, beaches, a large extent of saltmarsh and multiple islands (Natural England, 2017). Whilst the site appears to be estuarine, there is no significant freshwater input (Thomson et al., 2011). The SPA includes a marine area in Pennyhole Bay beyond the mouth of Hamford Water, consisting of subtidal habitats and Pye Sands, an intertidal sandbank. An area of intertidal beach below the cliffs of The Naze is also included within the SPA (Natural England, 2017).

1422. The complexity of habitats within the site, its mild climate and abundant invertebrate communities attracts a diverse and abundant community of waterbirds and wildfowl. It is an important refuge for waterbirds, especially during periods of severe winter weather on the continent (Natural England 2017). Non-breeding protected species include dark-bellied brent geese and shelduck. Overwintering waders, such as avocet, black-tailed godwit, ringed plover, grey plover, and redshank, are also designated species. There is an important little tern breeding colony within the SPA, however nesting is now restricted to the north-eastern side of Horsey Island.

1423. The main vulnerability of the SPA identified in the Natura 2000 citation is natural changes in sea level, leading to accelerated erosion of saltmarshes. This has been addressed in two ways; use of sand and gravels from dredging in Harwich harbour to reinforce existing beaches and protecting grazing marsh areas by reinforcing seawall toe with these materials in the most aggressive areas.

1424. Also identified as vulnerabilities are discharge from boats and from local sewage works, small industrial discharges, and disturbance due to yachts and accompanying watersports.

Table 8.3 Cited and current populations of qualifying features of Hamford Water SPA

Species	Cited SPA population (Indivs)	Current SPA population (Indivs)*
Little tern	39 pairs	Unknown
Avocet	99	813
Dark-bellied brent goose	5,650	5,657
Shelduck	840	1,089
Teal	3,630	4,041
Ringed plover	620	336
Grey plover	1,080	1,813
Black-tailed godwit	1,580	888
Redshank	1,240	1,844

* BTO Wetland Bird Survey (WeBS) core count data - five-year average from 2015-16 to 2019-20 (Frost et al, 2021).

8.2.2 Shadow Appropriate Assessment

8.2.2.1 Direct habitat loss to ex-situ habitats which support qualifying features

1425. The HRA Screening Report identified that direct habitat loss impacts on functionally linked land for qualifying features, outside of Hamford Water SPA, may occur.

1426. Usage of habitat within the onshore project area by qualifying features is species-specific and based on habitat preferences and ecology. Of the SPA qualifying features, most show preferences for the type of habitats found within the SPA such as intertidal mudflats and saltmarsh. This is reflected in the results of baseline surveys carried out along the onshore cable corridor(s) in the 2021-22 non-breeding season (see PEIR Appendix 24.4 (Volume III)) where most qualifying features were largely absent from areas outside of the SPA. A summary of findings, and assessment of potential effects on qualifying features is presented below.

8.2.2.1.1 Little tern

1427. Although no breeding season data for the onshore cable route are available, it is considered very unlikely that little terns would utilise any inland habitat, with species' preferences for coastal and marine SPA habitats described in the Natural England (2015) review of the proposed extension to the Hamford Water SPA for little tern. No loss of habitat would therefore occur due to the Project.

8.2.2.1.2 Waders and ducks

1428. Figures 24.9 to 24.12 of the PEIR show that around wader and duck activity recorded during the 2021-22 non-breeding season surveys (Appendix 24.4) was largely confined to the western part of the SPA around Beaumont Creek and outside of the onshore project area, with the exception of species such as lapwing, curlew and golden plover (not Hamford Water SPA qualifying features) that are known to travel further inland during winter than other wader species.

1429. The only SPA qualifying features recorded within or adjacent to the onshore project area during the 2021-22 non-breeding season surveys were shelduck and teal (note that these are not Ramsar site qualifying features). In most cases birds were recorded on or adjacent to waterbodies which would not be directly affected by cable construction, but flocks of up to 12 teal and five shelduck were recorded occasionally elsewhere within the onshore project area.

1430. Loss of habitats used by SPA qualifying features may compromise the SPA conservation objective 1 of maintaining or restoring the extent and distribution of the habitats of the qualifying features (Section 8.1.5), which may ultimately affect SPA populations. Habitat loss would most likely be temporary in nature, being associated with trenching and cable installation along the onshore cable corridor(s) during the construction phase (see Table 3.4 for worst-case parameters), although would also be applicable for the decommissioning phase if cables were removed.

1431. The cited SPA populations for teal and shelduck are 3,630 and 840 individuals respectively, and according to the latest WeBS core counts carried out for the BTO within the Hamford Water count sector (which approximates the SPA extent) the five-year average counts (2015-16 to 2019-20) were 4,041 teal and 1,089 shelduck (Frost et al. 2021).

1432. The onshore cable corridor(s) are predominantly comprised of agricultural (arable) habitats. It is likely that these habitats - particularly those away from waterbodies - would be of minor importance to non-breeding shelduck and teal from the SPA, and short-term loss of a relatively small extent of these habitats would not affect any individual's survival or productivity over a winter period. It should also be noted that even if these birds' survival were to be affected, the peak flock sizes recorded were well below 1% of the current SPA populations.

8.2.2.1.3 Dark-bellied brent goose

1433. No dark-bellied brent geese were recorded within or near the parts of the onshore project area closest to the SPA during the 2021-22 non-breeding season surveys (see PEIR Figure 24.9 (Volume II)) but were instead concentrated within the landfall search area (PEIR Figure 24.5 (Volume II)), located at least 3.3km from Hamford Water SPA.

1434. Rowell and Robinson (2004) undertook a thorough review of dark-bellied brent goose feeding ecology in the UK and note that historically, dark-bellied brent geese have fed exclusively on intertidal habitats, predominantly on mudflats, and also saltmarshes. Since the 1970s, inland feeding by large numbers of birds has become a regular occurrence at almost all the key sites in the southeast of England.

1435. Inland habitats used include grasslands (particularly fertilised grassland), winter cereals, oilseed rape, and occasionally recreation and sports grounds. Most sites used by the birds are within 5km from the coast, and they prefer large, open sites where they have clear sight lines.

1436. There is evidence that suggests the first habitats used when the birds arrive in autumn are intertidal, and that inland feeding only occurs once the intertidal resources have been depleted. By late winter/early spring, inland pasture has been shown to have a higher nutrient quality than saltmarsh resources, but this situation reverses as the spring progresses, which helps explain the general shift back to saltmarsh feeding in spring. The use of inland feeding sites is greatest at high tide, when the availability of intertidal food resources is limited.

1437. If it is assumed that based on the Rowell and Robinson (2004) review, dark-bellied brent geese may travel up to 5km to feed, then it is possible that the birds present within the landfall search area may comprise part of the Hamford Water SPA population, particularly during the late winter / early spring period.

1438. PEIR Figure 24.5 (Volume II) shows that the indicative landfall compound zone, where direct habitat loss associated with HDD works would occur, is occasionally used by brent geese, with flocks of up to 770 individuals, recorded in December 2020. This is approximately 13% of the current SPA population estimate of 5,657 individuals (Frost et al. 2021) and the cited SPA population.

1439. Whilst the arable land within the indicative landfall compound zone appears to be suitable for geese, at least for part of the winter, usage is relatively low and infrequent compared to within the adjacent Holland Haven Marshes SSSI. Direct habitat loss associated with HDD works at the landfall area may reduce the amount of habitat available to geese, potentially over two winters, but with the species commuting relatively widely, it is considered unlikely to affect the ability of geese to forage or roost successfully through the winter.

8.2.2.1.4 Conclusions

1440. Based on the above information presented, direct and indirect impacts on ex-situ habitats would be temporary, and limited in spatial extent. Results from baseline surveys suggest that the onshore project area is of limited importance for Hamford Water SPA qualifying features, and even where peak numbers represent a notable part of the SPA population (in the case of brent goose), frequency of occurrence is low. It is therefore unlikely that habitat loss would result in impacts on survival or productivity at a population level for any qualifying feature and as such, no AEoI of the Hamford Water SPA are predicted. It can also be reasonably concluded that no AEoI of the Hamford Water Ramsar site will occur.

8.2.2.2 Indirect disturbance of qualifying features from noise and visual disturbance

1441. In the HRA Screening Report, noise and visual disturbance were identified as potential impacts during construction and decommissioning of the Project.

1442. Construction activity associated with the landfall would last for up to 13 months, with HDD works taking place over up to six of these months as a worst-case.

The HDD works may include limited 24 hour / 7 days working programme where required during the HDD works. As a worst-case, assuming, for example, a November start (which is extremely unlikely), construction activity may overlap with up to two non-breeding seasons.

1443. Construction activities associated with the onshore cable corridor(s) and onshore substation may last for up to 24 months, which in a realistic worst-case scenario would likely affect two non-breeding seasons.

1444. The impacts of disturbance to non-breeding birds may extend beyond the onshore project area into surrounding habitat, including near or within Hamford Water SPA and Ramsar site. This is considered likely only if the far north-eastern cable corridor around Thorpe-le-Soken is chosen as the preferred cable corridor (see Figure 1-2). The extent of any disturbance is likely to be dependent on the species, the nature of the disturbance source and current baseline disturbance levels. In general, there is currently widespread and frequent human activity across parts of the onshore project area, in particular the landfall search area where dog walkers, runners, wildfowling, golfing, angling (at rocky jetties) and metal detecting are common. Inland, activities are likely to be related to agricultural production and walkers along Public Right of Ways (PRoWs), and so the construction programme would likely represent a material increase in activity in these areas of works.

8.2.2.2.1 Little tern

1445. In the Natural England (2015) review of the proposed extension to the Hamford Water SPA for little tern, it is noted that the only remaining colony is on Horsey Island which is over 3.5km from the onshore project area, meaning no nesting birds would be disturbed by construction activities. The feeding grounds of the little terns that nest at Horsey Island lie predominantly in marine areas in the shallower water along the edges and mouths of creeks and channels and the shallower waters around Pennyhole Bay and along the coastline, which again means no disturbance would occur.

8.2.2.2.2 Waders and ducks

1446. As noted under Impact 1 above, Hamford Water SPA qualifying features recorded during the 2021-22 non-breeding season surveys (Appendix 24.4, Volume III) were mainly recorded within the westernmost part of the SPA at Beaumont Creek, approximately 300m from the onshore project area, where there is suitable mudflat and saltmarsh habitat.

1447. Redshank was the qualifying wader feature most commonly recorded at Beaumont Creek, with birds feeding on saltmarsh and within small creeks. A single redshank was also recorded feeding in a muddy pool within a horse paddock closer to the onshore project area. Flock sizes were generally small, with a peak count of 10 individuals.

1448. Teals were present in flocks of up to 65 individuals in Beaumont Creek, and as noted in Impact 1, in lower numbers (up to 12 birds) on or near waterbodies inland.

1449. Single avocet and black-tailed godwit were recorded in Beaumont Creek on one occasion, and a peak of two grey plovers were recorded. Ringed plovers were absent.

1450. Whilst generally absent from Beaumont Creek, as noted above under Impact 1, up to five shelduck were present within more inland areas overlapping with or adjacent to the onshore project area.

1451. Beaumont Creek may therefore provide suitable feeding and roosting habitats for some SPA qualifying features, and at c. 300m distant from the onshore project area, it is possible that birds could be disturbed by construction activities, should they take place during the non-breeding season, and be of a nature that would induce alertness or displacement behaviour. Most sensitive times for disturbance would likely be at high tide when birds are roosting, particularly during cold temperatures.

1452. The area of SPA located within 500m of the onshore project area is located beside an active farm (Quay Farm) and a PRoW, and within 300m of a minor road, and so birds there are likely to be accustomed to some degree of human activity. The duration of works within c.300-500m of Beaumont Creek is likely to be short-term, but it is considered possible that the novel construction activity may disturb birds during this period. Based on survey counts, numbers of birds affected are however unlikely to reach importance within the context of SPA populations (Table 8.3), with the possible exception of teal, where just over 1% of the SPA population was recorded in this area during one survey visit.

1453. Teal, and other species such as redshank, are relatively sensitive to human presence, and so birds are likely to move from the Beaumont Creek area during the period of nearby construction, if taking place during the non-breeding season. On balance, the most likely outcome would be relocation to elsewhere within the SPA without affecting the winter survival rate of the populations. This is not considered likely to compromise conservation objective 4, relating to the population of the SPA, but may temporarily affect conservation objective 5 relating to the distribution of qualifying features within the site. However, since the extent of redistribution is likely to be small and short-term in duration, it is considered that within the context of the whole SPA, it would not be significant. This disturbance would only occur if the north-eastern cable corridor option around Thorpe-le-Soken is chosen (see Figure 1-2). If either of the other two corridors closer to Thorpe-le-Soken are chosen, the distance from the SPA would mean there would be no indirect disturbance to waders and ducks of Hamford Water SPA.

8.2.2.2.3 Dark-bellied brent goose

1454. No dark-bellied brent geese were recorded within or near Beaumont Creek during the 2021-22 non-breeding bird surveys Appendix 24.4, Volume III), but as outlined in Impact 1, birds recorded within the landfall search area approximately 3km away may be part of the Hamford Water SPA population.

1455. The landfall non-breeding bird surveys (Appendices 24.1 and 24.3, Volume III) recorded widespread and frequent human activity across large parts of the landfall search area during the non-breeding season, including dog walkers, wildfowling, golfing, angling (at rocky jetties) and metal detecting.

1456. The majority of the coastal strip (seawall to Kirby Brook) from Holland Haven to Frinton is used for recreational pursuits, so there is frequent potential disturbance to birds. During one of the non-breeding bird survey visits in late

December 2020, for example, a total of 23 dog-walkers with 30 dogs (some off leash), 28 joggers, 21 golfers and 50-100 non-dog walkers were noted. Some PRoWs in other parts of the landfall survey area were also in heavy use by walkers, and this includes within the indicative landfall compound zone.

1457. Three gas gun scarers were stationed in fields in and around the landfall survey area during winter months in 2021-22. These are likely to affect the current distribution and site usage of geese, with birds likely to move frequently between locations in response to disturbance sources. For dark-bellied brent goose, usage of the indicative landfall compound zone is relatively low and infrequent compared to other parts of the landfall search area, which may at least in part be due to current levels of disturbance. Additional disturbance associated with HDD works is therefore unlikely to affect the ability of geese to forage or roost successfully outside of Hamford Water SPA, if it is assumed that these birds already tolerate and cope with disturbance in the area.

8.2.2.2.4 Conclusions

1458. Based on the above information presented, disturbance impacts would be temporary, and limited in spatial extent. Results from baseline surveys suggest that the onshore project area is of limited importance for SPA qualifying features, and even in the case of brent goose where peak numbers represent a notable part of the SPA population, frequency of occurrence is low, which may be due to existing disturbance sources. The closest part of the SPA at Beaumont Creek does host relatively small populations of most of the qualifying features, and although in certain circumstances (non-breeding season, high tide roosts) birds may be disturbed, this is unlikely to impact on survival rates over a winter, or significantly affect SPA distributions.

1459. The PEIR Chapter 24 Onshore Ornithology (Volume I) outlines monitoring to ensure that no significant disturbance would occur, stating that “it is also anticipated that, depending on the final location of project infrastructure, monitoring of the Hamford Water SSSI non-breeding bird assemblages may be required to ensure that there are no significant construction disturbance effects”. This would also be relevant to the SPA and Ramsar site populations.

1460. It is therefore unlikely that disturbance would result in impacts on survival, productivity or distribution at a population level for any qualifying feature and as such, no AEoI of the Hamford Water SPA are predicted. It can also be reasonably concluded that no AEoI of the Hamford Water Ramsar site will occur.

8.2.2.3 Indirect impacts on habitats which support qualifying features from air quality emissions and changes in supporting surface or groundwater resources

1461. The HRA Screening Report identified that indirect effects on habitats supporting qualifying features may result due to air quality emissions (localised increases in nitrous oxides / particulate matter / dust) during construction or decommissioning. The Institute of Air Quality Management (IAQM, 2014) guidance recommends that an air quality assessment is required where there is “*an ‘ecological receptor’ within 50m of the boundary of the site; or 50m of the route(s) used by construction vehicles on the public highway, up to 500m from the site entrance(s)*”.

1462. Potential indirect impacts were also identified as resulting from changes in supporting surface or groundwater during all phases, the extent of which is dependent on habitat types.

1463. These impacts may compromise conservation objectives 2: The structure and function of the habitats of the qualifying features; and 3: The supporting processes on which the habitats of the qualifying features rely.

1464. Embedded mitigation for the project includes commitment to ensuring best practice pollution prevention measures are adhered to at all times to minimise the risk of pollutant release to sensitive habitats (see PEIR Chapter 21 Water Resources and Flood Risk, Volume I), and Best Practical Means to be employed during construction to limit dust, odour, and exhaust emissions during construction works, to reduce potential effects upon air quality-sensitive habitat (see PEIR Chapter 20 Onshore Air Quality, Volume I).

8.2.2.3.1 Little tern

1465. As noted above in Impacts 1 and 2, the little tern breeding colony and foraging habitats are sufficiently distant from the onshore project area, and so no indirect impacts are predicted.

8.2.2.3.2 Waders and ducks

1466. The most sensitive habitats for SPA qualifying features are considered as being saltmarsh at the edge of the SPA at Beaumont Creek, and watercourses, wetland and ponds used by qualifying features outside of the SPA.

1467. Although the SPA is around 300m from the onshore project area, connectivity is possible due to a watercourse that drains into Hamford Water which crosses the onshore cable corridor(s). Saltmarshes are sensitive to nutrient enrichment from sources such as construction-related runoff, pollution incidents or agriculture production, and excessive supplies of nitrogen has been associated with shifts in species' distribution and production, as well as marsh degradation and loss (Brittney et al. 2018). This in turn may affect prey and food sources for SPA qualifying features such as redshank and teal found in that area. Although not directly affected by habitat loss, it is also possible that watercourses, waterbodies and wetlands used by teal and shelduck may also be affected by any unmitigated pollution incidents.

1468. As part of the Project’s embedded mitigation (see Table 8.2), the watercourse which drains into Hamford Water 300m upstream of Beaumont Quay is proposed to be crossed using trenchless techniques (e.g. HDD), meaning there will be no direct interaction with the watercourse. In addition, as noted in Table 8.2 a HDD Method Statement and ‘Break-out’ Contingency Plan will be prepared in advance of construction which will detail the measures to be taken in the event of a drilling fluid breakout in order to minimise effects upon watercourses. Draft versions of these documents will be submitted with the Project’s DCO application to provide assurance that reasonable steps will be taken to minimise the risk of effects arising as a result of ‘break-out’ during HDD beneath watercourses, thus reducing the risk of downstream, effects upon the saltmarsh habitats at Beaumont Quay. As the extent and duration of indirect impacts are likely to be small and short-term, particularly when the embedded mitigation measures are adhered to, and the number of birds likely to be affected is relatively small (see Impacts 1 and 2 for details) they are unlikely to compromise any of the conservation objectives.

1469. Chapter 20 Onshore Air Quality (Volume I) undertook an assessment of the potential for a 1% threshold of the site relevant critical loads for nitrogen oxides, ammonia, nitrogen and acid deposition to be exceeded due to changes in road traffic predicted during the project's construction. This exercise determined that it is unlikely there would be an exceedance of the 1% threshold for any of the identified pollutants at Hamford Water SPA.

8.2.2.3.3 Dark-bellied brent goose

1470. Dark-bellied brent goose records within the onshore project area were confined to the landfall search area, where landfall HDD works would take place. During the drilling process there is the potential for the release/breakout of inert drilling fluids which may impact the watercourses and waterbodies within and around Holland Haven Marshes and in turn result in indirect impacts upon geese due to contamination of aquatic and wetland habitats.

1471. As part of the project's embedded mitigation, the HDD will be designed considering the ground conditions to minimise the risk of a breakout where possible. A HDD Method Statement and 'Break-out' Contingency Plan will be prepared in advance of construction which will detail the measures to be taken in the event of a drilling fluid breakout in order to minimise effects upon watercourses. Draft versions of these documents will be submitted with the Project's DCO application to provide assurance that reasonable steps will be taken to minimise the risk of effects arising as a result of 'break-out' during HDD beneath Holland Haven Marshes SSSI.

1472. Impacts on river and wetland habitats due to break-outs are assessed in PEIR Chapter 23 Onshore Ecology (Volume I), taking into consideration the embedded mitigation. These are determined to be either negligible or low magnitude up to medium-term, and it therefore follows that impacts on dark-bellied brent geese would also be of low likelihood.

8.2.2.3.4 Conclusions

1473. Based on the above information presented, particularly with embedded mitigation, indirect impacts would be unlikely, and if occurring would be temporary, and relatively limited in spatial extent. Results from baseline surveys suggest that the onshore project area is of limited importance for SPA qualifying features, and even in the case of brent geese, where peak numbers represent a notable part of the SPA population, frequency of occurrence is low. The closest part of the SPA at Beaumont Creek comprises sensitive saltmarsh habitat and does host relatively small populations of most of the qualifying features. Although it is possible that in the unlikely event of a pollution incident in a connecting watercourse impacts would reach the SPA, the extent or duration is unlikely to impact on survival rates of qualifying feature populations over a winter.

1474. It is therefore unlikely that indirect impacts would result in material effects on survival, productivity or distribution at a population level for any qualifying feature and as such, no AEoI of the Hamford Water SPA are predicted. It can also be reasonably concluded that no AEoI of the Hamford Water Ramsar site will occur.

8.3 Stour and Orwell Estuaries SPA and Ramsar site

8.3.1 Site overview

1475. A list of qualifying features for the Stour and Orwell Estuaries SPA and Ramsar site are presented in Table 4.3, and cited and current populations are given in Table 8.4. The SPA and Ramsar site are similar in extent and because impacts are likely to be similar, the assessment of effects on the integrity of the SPA is also applicable to the Ramsar site, unless specifically noted.

1476. Stour and Orwell Estuaries SPA is approximately 3.3km to the north of the onshore project area at its closest point (see PEIR Figure 24.1 (Volume II)). The Estuaries are adjacent but combine near the mouth as they join the North Sea. Both are tidal, shallow and relatively sheltered, although the Orwell Estuary is narrower and more linear compared to the wider Stour Estuary.

1477. Invertebrate-rich mudflats flank the edges of both estuaries, regularly being covered and uncovered by the tide. The Stour Estuary in particular has extensive mudflats due to the wider and more intertidal channel, with large areas found within the main bays. Several small areas of seagrass (*Zostera* spp.) are found across the mudflats and diverse communities of saltmarsh fringe the edges of both estuaries. Several freshwater pools and grazing marshes fall within the SPA boundary, such as Trimley and Shotley Marshes.

1478. The SPA hinterlands include large areas of arable agricultural land, as well as several major urban areas, including Ipswich at the head of the Orwell Estuary, and the towns of Harwich and Felixstowe at the mouth of the estuaries.

1479. Breeding avocet feed upon the intertidal mudflats and use the grazing marshes to nest during the summer. The SPA also supports important numbers of overwintering waterbirds, which also use the mudflats extensively for feeding. The saltmarsh and grazing marsh provide important roosting sites, whilst some birds feed and roost on the surrounding arable land.

Table 8.4 Cited and current populations of qualifying features of Stour and Orwell Estuaries SPA

Species	Cited SPA Population (Indivs)	Current SPA Population (Indivs)*
Avocet (breeding, SPA only)	21 pairs	279 + 185 (individuals)
Dark-bellied brent goose	2,627	2,407 + 942
Redshank	2,588	1,450 + 1,003
Pintail	741	364 + 112
Grey plover	3,261	1,414 + 492
Knot	5,970	12,632 + 853
Dunlin	19,114	10,440 + 4,163
Black-tailed godwit	2,559	2,370 + 843

Redshank	3,687	1,450 + 1,003
Non-breeding waterbird assemblage including: Lapwing Cormorant	 1,283 + 796** 5,537 + 2,579**	 1,173 + 478 1,849 + 1,405

* BTO WeBS core count data - five-year average from 2015-16 to 2019-20 for Stour Estuary + Orwell Estuary sectors combined (Frost et al, 2021).

** BTO WeBS core count data - five-year average from 1995-96 to 1999-2000 for Stour Estuary and Orwell Estuary sectors combined (Frost et al, 2021). This year range is consistent with the data used to determine the cited SPA populations.

8.3.2 Shadow Appropriate Assessment

1480. Most of the SPA qualifying features show preferences for the type of habitats that are found within the SPA but not in the onshore project area, such as intertidal mudflats and saltmarsh. This is reflected in the results of baseline surveys carried out along the onshore cable corridor(s) in the 2021-22 non-breeding season (see Appendix 24.4, Volume III) where most qualifying features were absent.

1481. For the purposes of the assessment, it is assumed that any qualifying species found in proximity to the Hamford Water SPA (e.g. redshank, teal, see Impacts 1 and 2) belong to that SPA, and for most species, connectivity with the Stour and Orwell Estuaries SPA is only considered possible if individuals were recorded in the northern half of the onshore cable corridor(s) or onshore substation zone (within up to 10km of the Stour and Orwell Estuaries SPA).

1482. Based on the results of the 2021-22 non-breeding season surveys, occurrences of most qualifying features within the onshore project area and within 10km of the SPA were rare. Concentrations of waterbirds were recorded by waterbodies at Stacie's Farm, over 2km north of the onshore project area, but the only species regularly recorded within or adjacent to the onshore project area were SPA assemblage species, lapwing and curlew (PEIR Figure 24.10 (Volume II)). Cormorant, another assemblage species, was also regularly recorded across the onshore project area.

1483. For curlew, the closest aggregation of records was around 5.5km to the south of the Stour and Orwell Estuaries SPA, and around 3.5km to the northwest of the Hamford Water SPA (PEIR Figure 24.10 (Volume II)). Curlews are known to utilise inland areas near coasts during winter months, but according to Musgrove et al. (2011) these are thought likely to form only a small proportion of the total national wintering population. In a study of waders on the Ribble Estuary, Greenhalgh (1975) found that curlew was an inland-feeder as well as shore-feeder, particularly at high tides.

1484. There is a lack of evidence to determine how far inland curlews may travel to feed or roost, but in a study of wintering movements of three tagged curlews in the Cefni Valley, birds flew up to 4.5km inland from the Newborough Warren estuary to grassland/pasture fields (BTO, 2021). If it is assumed that this distance is representative of the behaviour of curlews locally, then birds present in the central part of the onshore project area are most likely to belong to the closer Hamford Water population (five-year mean of 863 individuals, Frost et al. 2021), where the species is not a qualifying feature. As such, no adverse effects on the Stour and Orwell SPA curlew population are predicted.

1485. Cormorants were regularly recorded during surveys, but most observations were made either of birds in flight, or to the north of the onshore project area on waterbodies or watercourses. Habitats within the onshore project area are generally unsuitable for the species. Additionally, cormorants are considered to be of low sensitivity to disturbance, with birds commonly being found in close proximity to humans, e.g. along urban rivers or in coastal ports. As such, no adverse effects on the Stour and Orwell SPA cormorant population are predicted.

1486. The focus of the assessment is therefore on lapwing, with no adverse effects predicted for all other qualifying features.

8.3.2.1 Direct habitat loss to ex-situ habitats which support qualifying features

1487. The HRA Screening Report (Appendix 1) identified that direct impacts on functionally linked land for qualifying features, outside of Stour and Orwell Estuaries SPA, may occur.

8.3.2.1.1 Lapwing

1488. Gillings and Fuller (1999) provided a review of studies on wintering lapwing. They found that the species can be observed on winter cereals, bare till and on a variety of grassland types, including pastures and airfields. Most studies of habitat use that the authors reviewed reported a strong preference for feeding on grassland, particularly permanent pastures and this apparent preference for grassland could explain the rather low lapwing densities which have been recorded in the largely arable landscape of East Anglia in mid-winter.

1489. Gilling and Fuller's study reported that during surveys, lapwings made movements of up to 6km from daytime roosts. More local movements appear to be common, and flocks can be extremely mobile within winters. A typical pattern observed was that birds may use one or two particular areas of farmland for several weeks and then move to another area, which may be several kilometres away. The authors concluded that the notion of 'traditional sites' needs to be treated with caution and found that on much farmland the birds are extremely localised and large areas of apparently suitable habitat are typically unused within any winter.

1490. PEIR Figure 24.10 (Volume II)shows that in the northern half of the onshore project area, most lapwing records during winter 2021-22 were in arable fields more than 400m from the onshore project area. There was, however, a concentration of usage in closer proximity to the onshore substation zone where counts of up to 125 individuals were made. Notwithstanding this, the evidence does show that based on the records from 2021-22, usage within the onshore project area itself is low.

1491. Birds present around the onshore substation zone are likely to be from the Stour and Orwell Estuaries SPA, although they may on occasion use fields within the onshore project area for feeding or roosting. Overall impacts of permanent direct habitat loss would be small and localised, as it is evident from survey results that alternative habitat nearby would likely be available. Therefore over the course of a winter, direct habitat loss is unlikely to affect the survival rates within the lapwing SPA population.

8.3.2.2 Indirect disturbance of qualifying features from noise and visual disturbance

1492. In the HRA Screening Report, noise and visual disturbance were identified as potential impacts during construction and decommissioning of the Project.

8.3.2.2.1 Lapwing

1493. From studies carried out in West Sussex (Shrubb, 1988) and Hampshire (Milson et al. 1985) feeding and roosting lapwings demonstrated a preference for the most open habitats or for large fields, potentially to minimise predation and human disturbance risks. Cutts et al. (2013) considered lapwing to be of moderate sensitivity to disturbance and recommended a disturbance distance of around 300-400m for lapwing when planning operations at estuarine sites, but a smaller distance when inland.

1494. Evidence therefore suggests that the main areas of lapwing activity recorded between the Stour and Orwell Estuaries SPA and the onshore project area are beyond potential disturbance range. Within the 400m study area, most recorded activity was near the onshore substation zone, and it is therefore possible that birds may be displaced from fields within and surrounding this area, depending on agricultural practices at the time of construction. Disturbance may also continue into the operational phase of the onshore substation, albeit this is likely to be of a smaller extent, and less frequent if associated with maintenance activities.

1495. Displacement from potential feeding habitat around the part of the onshore substation zone that would be selected for construction may reduce the overall habitat available for lapwings during the non-breeding season. However, this is unlikely to be at a level that would be significant for the population, based on the recorded distribution and low importance of the onshore project area. No impacts on survival rates are likely to occur over a winter.

8.3.2.3 Indirect impacts on habitats which support qualifying features from air quality emissions and changes in supporting surface or groundwater resources

1496. The HRA Screening Report identified that indirect effects on habitats supporting qualifying features may result due to air quality emissions or from changes in supporting surface or groundwater during all phases, the extent of which is dependent on habitat types.

8.3.2.3.1 Lapwing

1497. Shrubb (1988) found that the main driver for lapwing feeding sites appeared to be the organic matter content of the soil, which significantly affects the population levels of soil and surface-dwelling invertebrates present. Disruption to the regular agricultural crop rotation due to trenching and cable installation may therefore temporarily reduce organic concentrations in the soil, although this is likely to be limited to within the onshore project area and reversible over the short- or medium-term. Pollution incidents within large arable fields preferred by lapwings would unlikely be diffuse, based on ground conditions, unless close to a watercourse. This is however unlikely to affect feeding birds (by a reduction in prey density or contamination of prey), assuming that they would already be displaced from the area around ongoing construction works (Impact 2).

1498. Chapter 20 Onshore Air Quality (Volume I) undertook an assessment of the potential for a 1% threshold of the site relevant critical loads for nitrogen oxides, ammonia, nitrogen and acid deposition to be exceeded due to changes in road traffic predicted during the project's construction. This exercise determined that there is likely to be an exceedance of the 1% threshold for all four of the identified pollutants at Hamford Water SPA. These exceedances vary between 1.3% of the critical load of nitrogen deposition, to 3.2% of the critical load for ammonia. The represents extremely small exceedances of the critical loads, which themselves will only occur at peak times in the construction programme. This is therefore not anticipated to result in measurable changes to the structure of nitrogen sensitive habitats within the SPA.

1499. Overall the risk of indirect impacts on supporting habitats is low (not at least due to embedded mitigation based on best practice as outlined above for Hamford Water SPA) and, if it did occur, would be small-scale and reversible. No effects on the SPA population are therefore predicted.

8.3.2.3.2 Conclusions

1500. Based on the above information, lapwing is the only SPA and Ramsar site species (as part of the non-breeding assemblage) that was found regularly and in sufficient numbers within the 400m study area, to be considered for assessment.

1501. Occurrence of lapwings within the onshore project area was still however relatively low and the limited extent of direct habitat loss, mainly associated with the onshore substation, is not considered important to the SPA population. As indirect impacts would be temporary and relatively limited in spatial extent, particularly with embedded mitigation, no impacts on lapwing survival rates over a winter are predicted.

1502. It is therefore unlikely that any impacts would result in material effects on survival, productivity or distribution at a population level for any qualifying feature (or assemblage species). As a result, no AEoI of the Hamford Water SPA are predicted. It can also be reasonably concluded that no AEoI of the Hamford Water Ramsar site will occur.

8.4 Colne Estuary (Mid-Essex Coast Phase 2) SPA and Ramsar site

8.4.1 Site overview

1503. A list of qualifying features for the Colne Estuary SPA and Ramsar site are presented in Table 4.3. The SPA and Ramsar site are similar in extent and because impacts are likely to be similar, the assessment of effects on the integrity of the SPA is also applicable to the Ramsar site, unless specifically noted.

1504. Colne Estuary SPA is just over 7km west of the onshore project area at its closest point, and around 9km from the landfall search area (see PEIR Figure 24.1 (Volume II)). It is an integral component of the five phased Mid-Essex Coast SPAs, and supports internationally important populations of breeding birds, as well as internationally important assemblages of wintering waterfowl, present in both nationally and internationally important numbers. The Mid-

Essex Coast comprises an extensive complex of estuaries and intertidal sand and silt flats, including several islands, shingle and shell beaches and extensive areas of saltmarsh (English Nature, 1993).

1505. The diversity of estuarine habitats provides good quality feeding areas for a diversity of waterbird species. At high tide, the birds roost along the shoreline and salt marsh fringe.

Table 8.5 Cited and current populations of non-breeding qualifying features of Colne Estuary SPA

Species	Cited SPA Population (Indivs)	Current SPA Population (Indivs)*
Hen harrier	19	Unknown
Dark-bellied brent goose	5,315	2,847
Redshank	1,252	1,201
Cormorant	243	227
Mute swan	354	24
Shelduck	1,237	646
Goldeneye	262	2
Ringed plover	355	179
Grey plover	1,168	599
Sanderling	219	192
Dunlin	11,272	3,483
Black-tailed godwit	606	1,121
Curlew	938	351

* BTO WeBS core count data - five-year average from 2015-16 to 2019-20 for Colne Estuary sector (Frost et al, 2021).

8.4.2 Shadow Appropriate Assessment

1506. The Colne Estuary SPA lies further from the onshore project area than the other two SPAs considered above, as well as from the Holland Haven Marshes SSSI. Likely connectivity between the onshore project area and the Hamford Water SPA and Stour and Orwell Estuaries SPA has already been established above for some qualifying features, and it therefore follows that birds recorded within the onshore project area are less likely to be from the Colne Estuary SPA. Although the HRA Screening Report screened in the SPA due to theoretical connectivity within a 10km study area, a further screening of likely connectivity for qualifying features, based on evidence provided above, is required.

1507. For qualifying features that are breeding species (little tern, pochard and ringed plover), based on the distances of the SPA to the onshore project area, it is considered that there is no connectivity, and no effects would occur.

1508. Most of the SPA non-breeding season qualifying features show preferences for the type of habitats that are found within the Colne Estuary SPA but not in most of the onshore project area. The possible exception being the landfall search area within Holland Haven Marshes SSSI (see Section 8.5) and inland feeding areas that may be used by the most wide-ranging qualifying species, dark-bellied brent geese and curlew, both of which are considered below.

8.4.2.1 Curlew

1509. As noted previously, curlews can travel to feed up to around 5km inland from estuarine sites. Most inland concentrations of curlews were found within 4-5km of Holland Haven Marshes SSSI and Hamford Water SPA (PEIR Figure 24.10 (Volume II)), suggesting that birds present within the onshore project area are likely to be those that roost and spend most of their time within these designated sites, rather than from Colne Estuary SPA. Therefore, although it cannot be completely discounted that curlews from the Colne Estuary SPA would travel to feed or roost within the onshore project area (see section 8.5 below), the frequency of occurrence, and importance of the area for SPA birds is likely to be low. No adverse effects on the Colne Estuary SPA curlew population are therefore predicted.

8.4.2.2 Dark-bellied brent goose

1510. Wood (2007) states that there are nine separate large wintering flocks of dark-bellied brent geese in Essex with little interchange between them, with the Colne Estuary hosting two flocks, and single flocks at Hamford Water and on the Stour Estuary. It is also stated that in years of high numbers, brent geese may move up to 4km inland to feed. Rowell and Robinson (2004) also identified two dark-bellied brent goose flocks that winter on the Colne Estuary. The larger flock’s main feeding area was at a reserve at East Mersea and the smaller flock was found around Colne Point. In the winters of 2001/02-2002/03 there was no evidence of inland feeding at Colne Point, as there was sufficient food on the saltmarshes to sustain the flock of several hundred brent geese.

1511. Rowell and Robinson (2004) also note that in years when there have been high numbers (up to 1,000) birds from Hamford Water have moved south to Holland Haven.

1512. Overall, it is therefore considered that based on the historic evidence provided and relative distances of SPAs from Holland Haven, geese present occasionally within and around the landfall search area are likely to be from the closer Hamford Water SPA population. No adverse effects on the Colne Estuary SPA dark-bellied brent goose population are therefore predicted.

8.5 Holland Haven Marshes: Potential Usage as a Refuge

1513. During most of the winter, the Holland Haven Marshes SSSI non-breeding bird assemblage is likely to be sedentary and separate from the three SPA assemblages. It is, however, possible that, for example during periods of extreme cold weather and/or disturbance events such as wildfowling, coastal birds may undertake larger movements between estuaries. Holland Haven Marshes SSSI could therefore also be an occasional refuge at sensitive times for SPA qualifying features. In order of likelihood of origin, based on distances to Holland Haven Marshes SSSI, this would be birds from Hamford Water SPA, Colne Estuary SPA, then Stour and Orwell Estuaries SPA.

1514. Table 8.6 provides an indication of peak flock sizes of species that are nearby SPA qualifying features recorded at Holland Marshes, during monthly WeBS counts, and non-breeding season surveys undertaken for the project (Appendix 24.1 and Appendix 24.3). Although large-scale movements may be brief and occur during darkness (therefore may be easily missed) the results of both studies provide an indication of peak usage at Holland Marshes, placed within the context of the nearest SPA populations.

Table 8.6 Current populations of non-breeding qualifying features of SPAs and of Holland Haven Marshes (shaded = SPA qualifying feature)

Species	Holland Marshes – Webs Five Year Mean Count	Holland Marshes – Peak Survey Count	Hamford Water	Colne Estuary	Stour And Orwell Estuaries
Dark-bellied brent goose	821	110	5,657	2,847	3,349
Redshank	7	5	1,844	1,201	2,453
Cormorant	12	232**	562	227	3,254*
Mute swan	3	7	49	24	426
Shelduck	33	19	1,089	646	2,393
Goldeneye	0	0	2	2	150
Ringed plover	1	0	336	179	443
Grey plover	0	3	1,813	599	1,906
Sanderling	0	1	79	192	122
Dunlin	5	6	5,203	3,483	14,603
Black-tailed godwit	46	21	888	1,121	3,213
Curlew	28	54	863	351	1,651
Teal	398	324**	4,041	789	2,548
Pintail	2	16**	83	13	476
Knot	0	1	5,191	1,278	13,485
Lapwing	476	137	2,716	1,344	1,651*
Avocet	36	42	813	532	185

* Considered within context of non-breeding assemblage only. ** includes counts of birds on sea

1515. For most species, including those such as dunlin, knot, grey plover and redshank that are numerous elsewhere, Holland Marshes appears to be unimportant, with low peak counts. For some, such as dark-bellied brent goose, cormorant, curlew, lapwing and teal, peak numbers can be higher, although still proportionately quite small compared to nearest estuary SPA populations.

1516. It is possible, under a worst-case scenario, that the HDD temporary construction compound would be located within 300m of the Holland Marshes lagoon, which hosts highest numbers of birds during the non-breeding season. If that was the case, disturbance due to noise and visual impacts (Impact 2) or less likely, indirect impacts on habitats such as HDD ‘break-outs’ (Impact 3) during construction may prevent SPA birds from using the lagoon as a refuge during one or two winters.

1517. The possible impacts of HDD works on the Holland Haven Marshes SSSI assemblage were assessed as part of the PEIR Chapter 24 Onshore Ornithology (Volume I), and a worst-case unmitigated effect of moderate to major adverse on the SSSI non-breeding assemblage was predicted due to disturbance. This conclusion is based on the impacts on the resident populations which are likely to depend more on the SSSI, rather than those populations from nearby SPAs which occasionally use it. To address this effect on the SSSI however, the following additional mitigation was provided:

1518. As part of efforts to reduce the impact of construction disturbance, the Project’s design process will seek to avoid locating HDD works and construction of the onshore cable route respectively within a position which would give rise to disturbance effects upon the SSSI non-breeding assemblage associated with the Holland Haven Marshes lagoon. This process will be informed by the results of the two years’ worth of baseline surveys, and will be reported on within the Project’s DCO submission.

1519. In addition, measures will be adopted to minimise noise, light and disturbance on key aggregations of non-breeding birds, such as keeping existing hedgerows and vegetation for visual screening, or the installation of additional solid or acoustic fencing around compounds or noisy plant, where considered necessary. This is of particular relevance to the landfall HDD works near the Holland Haven Marshes SSSI. Details of such measures would be set out in the EMP.

1520. Based on the assumption that the HDD temporary construction compound would be located sufficient distance from the lagoon to minimise disturbance, as well as indirect impacts, it can reasonably be assumed that SPA birds would be able to continue to use Holland Marshes as an occasional refuge, and no AEoI of any SPAs would result.

8.6 Conclusions on AEoI to SPAs and Ramsar Sites

1521. The above sections have provided an assessment of potential direct and indirect impacts that may result from the project’s construction, operation and decommissioning, on qualifying features of nearby Hamford Water SPA, Stour and Orwell Estuaries SPA and Colne Estuary SPA, and their associated Ramsar sites.

1522. In general, usage of the onshore project area by qualifying features was sufficiently low and infrequent to be able to confidently conclude that the distribution, survival or productivity of populations would be unaffected, and consequently no AEoI of any SPA or Ramsar site would occur, particularly when embedded and additional mitigation measures are considered.

8.7 In-combination effects

1523. The in-combination assessment requires the identification of the other plans, projects and activities that may result in in-combination effects (described as 'project screening'). This information is set out in Table 24.18 of the PEIR, Chapter 24 Onshore Ornithology (Volume I), together with a consideration of the relevant details of each, including current status (e.g. under construction), planned construction period, closest distance to the North Falls project, status of available data and rationale for including or excluding from the assessment.

1524. The project screening was informed by the development of a project list which forms an exhaustive list of plans, projects and activities within 10km of the onshore project area. The list was appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out.

1525. For the purposes of this draft RIAA, the scope of the in-combination assessment is similar to that described in Section 24.8 Cumulative Effects of the PEIR Chapter 24 Onshore Ornithology (Volume I). Based on the project screening in Table 24.18 of PEIR Chapter 24, two of the listed projects are to be included in the in-combination assessment: Five Estuaries OWF and East Anglia GREEN high voltage network reinforcement between Norwich, Bramford and Tilbury.

1526. Further details about both these projects are given in PEIR Chapter 4 Site Selection and Assessment of Alternatives (Volume I). Due to both projects being in the early stages of planning, currently only limited details are available for both.

8.7.1 In-combination Construction Effects

8.7.1.1 Five Estuaries

1527. The Five Estuaries onshore search area largely overlaps with the North Falls onshore project area. The Five Estuaries onshore search area will include a landfall, onshore cable corridors and onshore substation, although exact location details are not known at this stage. The overlapping nature of both project areas means that the Five Estuaries construction activities will very likely affect the same SPA qualifying features as those for the North Falls project.

1528. In the Five Estuaries Scoping Report, there is a commitment to using trenchless techniques at landfall, crossing Holland Haven Marshes SSSI.

1529. The potential for additional in-combination habitat loss or disturbance impacts is considered to be relatively low if there is also temporal overlap in construction activities. The working width should the two projects be constructed simultaneously will be wider (but still within the assessed onshore project area) however, the increase in habitat loss and disturbance is unlikely to change the likelihood of impacts on survival rates or productivity for qualifying features at a population level.

1530. North Falls is planned for construction from 2026 at the earliest, compared to 2028 to 2030 for Five Estuaries and so the possibility of sequential construction still exists. This means that it is likely that the duration that qualifying features will be subject to habitat loss and disturbance will increase. Whilst again this is unlikely to change the overall likelihood of an adverse effect at a population level, it may be the case that unmitigated adverse effects are more likely to occur because more non-breeding seasons may be affected. These will be mitigated for by the measures presented in Section 8.5, to avoid an adverse in-combination effect on the integrity of any SPA or Ramsar site.

8.7.1.2 East Anglia GREEN

1531. A new onshore substation is proposed to be built as part of the East Anglia Green proposals by National Grid, close to the preferred location for the North Falls onshore substation. North Falls is planned for construction from 2026 at the earliest, compared to 2027 to 2031 for East Anglia Green.

1532. It is likely that similar qualifying features will be affected by the construction of the East Anglia Green onshore substation, with lapwing from the Stour and Orwell Estuaries SPA most likely to be affected (Section 8.3.2). Assuming a similar location and size of substation as that planned for North Falls, a larger area of habitat for feeding may be affected due to habitat loss and/or construction disturbance. It is however considered unlikely that the scale of loss would make a material difference to the SPA population and therefore no adverse in-combination effects are predicted.

8.7.1.3 Conclusions

1533. Based on the likelihood that the likelihood of adverse effects would remain unchanged from that predicted for the project alone, it can be reasonably concluded that there would be no AEoI of any SPA or Ramsar sites, due to in-combination construction effects.

8.7.2 In-combination Operational Effects

8.7.2.1 Five Estuaries and East Anglia GREEN

1534. Due to the potential close proximity of both projects' substations, there is potential for in-combination effects, particularly to lapwing. Mitigation measures were outlined in PEIR Chapter 24 Onshore Ornithology (Volume I) in order to reduce potential operational lighting effects, including development of an Operational Lighting Plan, plus effective screening as mitigation were required to ensure no significant effects would occur as a result of the operation of North Falls. Even though little information is available on the operation of the Five Estuaries or East Anglia GREEN onshore substations, if similar light and noise emissions are produced, displacement of lapwing across a larger area may result. This is however unlikely to change the likelihood of an adverse effect at a population level.

8.7.2.2 Conclusions

1535. Based on the low likelihood that any qualifying feature or assemblage feature of the SPAs or Ramsar sites would be affected by operational impacts, it can be reasonably concluded that there would be no AEoI of any SPA or Ramsar sites, due to in-combination operational effects.

8.8 Overall Conclusion

1536. The evidence presented above indicates that, when taking into consideration mitigation, no AEoI of the Hamford Water SPA and Ramsar site, Stour and Orwell Estuaries SPA and Ramsar site, or Colne Estuary SPA or Ramsar site, will occur due to the project, either alone or in-combination with other projects.

9 Onshore SACs

9.1 Approach to assessment

1537. This section provides information to determine whether an AEoI of any onshore SAC sites may result due to impacts of the project on ecological qualifying features.

1538. The assessment follows the HRA process outlined in Section 2 and is based on the onshore project description in Section 1.4. It should be read in conjunction with:

- North Falls HRA Screening Report (Appendix 1);
- PEIR Chapter 23: Onshore Ecology (Volume I); and
- PEIR Onshore Ecology Appendices 23.1 to 23.7 (Volume III).

9.1.1 Consultation

1539. The onshore HRA Screening Report was submitted to the relevant ETGs on 2nd November 2022, and discussed in an ETG meeting on 15 November 2022. The following stakeholders were consulted as part of the ETG:

- Natural England;
- RSPB;
- Essex Wildlife Trust;
- Essex County Council;
- Tendring District Council; and
- Environment Agency.

1540. The consultation responses relevant to the RIAA which have been received to date are summarised in Table 8.1.

Table 9.1 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
Tendring District Council (Places Services)	15/11/2023 Onshore Ecology and Ornithology Expert Topic Group Meeting 2	If any of the SSSI features which underpin the qualifying features of European sites were identified as potentially subject to effects during construction or operation of the project, and therefore potentially giving rise to LSE upon the qualifying features, this will need to be taken into account during the HRA screening.	Features which support European sites have been considered in both the screening and in this draft RIAA.
Natural England	02/12/2022 Comments on HRA Screening Report	We note that North Falls has chosen an area of 10km for the desk-based study area for designated sites, and the rationale for this buffer should be provided. However, we advise that the scoping area should be based on the potential for species to be present within the area, the IRZ for designated sites as available on Magic, the ecology, i.e. foraging areas of designated species of sites in proximity to the proposed development area, and consideration given to Functionally Linked Land. We repeat our earlier advice, that the onus is on the Applicant to determine whether there is sufficient information/evidence to exclude areas from the desk-based study and for surveys.	NFOW are comfortable that the 10km buffer used for the initial 'sift' of sites for consideration within the HRA screening is the right buffer to use – this has been selected as the largest buffer from the various buffers used when considering different potential indirect effects (see Table 9.1). The largest buffer relates to effects upon ex-situ habitats, and here the 10km buffer has been used based on existing literature which identifies that potential foraging ranges of up to 10km for typical geese and wader species of the east of England can commonly occur from core feeding grounds (Hearn, 2004; Gillings and Fuller, 1999). NFOW notes that SSSI Impact Risk Zones for the SSSI which underpin the European & Ramsar sites considered in the HRA Screening extend at most to 5km, so all are covered by using this 10km buffer for the initial sift. Please note a further, more detailed sift of potential likely significant effects requiring further consideration in the Appropriate Assessment which considers different buffers for different indirect effects described in Table 9.1, is set out in Table 9.4 of the HRA Screening Report (Appendix 1).

Consultee	Date / Document	Comment	Response / where addressed in the RIAA
Natural England	10/02/2023 Further comments on HRA Screening Report	*[Response to NFOW comments]* We are content with the sites that have been scoped into the assessment, however, we advise that the Project should be mindful of the IRZs, foraging areas of designated species, and FLL on a site-by-site basis.	Sites screened in detailed in HRA Screening Report (Appendix 1) and summarised in Section 4.5.
Natural England	02/12/2022 Comments on HRA Screening Report	We also advise that the project should fully consider cumulative impacts for the different construction scenarios with Five Estuaries e.g. concurrently, sequentially etc., as was discussed in the ETG.	NFOW agree and have considered the Five Estuaries project within the in-combination assessment, using the most up-to-date information shared with NFOW by the project at the time of writing.
Natural England	02/12/2022 Comments on HRA Screening Report	Water Quality and Quantity - Depending on the final red line boundary and infrastructure area it may be necessary to consider potential impacts to water tables and water quality and quantity in relation to designated sites and features within the water catchments.	NFOW agree, and this has been considered within the screening and within this RIAA, with such potential effects upon Hamford Water screened in for further assessment.

9.1.2 Worst case scenario

1541. The worst-case scenarios for construction, operation and decommissioning related to the onshore project area are presented in Section 3. The shadow appropriate assessments for each designated site screened in (Section 4) have been based on these worst-case scenarios.

9.1.3 Embedded mitigation

1542. This section outlines the embedded mitigation relevant to the onshore SAC assessment, which has been incorporated into the design of North Falls (Table 8.2).

Table 9.2 Embedded mitigation measures

Parameter	Mitigation measures embedded into North Falls design
All receptors	Prior to works commencing, North Falls will prepare an EMP setting out full details of the ecological mitigation measures which will be adhered to during the Project's construction. This will include: • A programme of works; • A list of roles and responsibilities for ecological mitigation, including the role of an ECoW; • A plan showing ecological constraints; • Full details of best practice mitigation required in relation to all species and habitats affected by the Project; • Full details of any project-specific mitigation identified within this chapter, including habitat creation or protected species mitigation programmes. Any such programmes will be accompanied by mitigation layout plans; • A list of protected species licences and site consents required to facilitate construction; • Habitat reinstatement method statements for all habitats proposed to be reinstated following the completion of construction (including grassland, hedgerows, watercourses and arable field margins – see below); • Any associated standalone mitigation plans, e.g. reptile precautionary method of works, invasive species management plan, etc. as required. The EMP will include details of best practice for minimising impact to notable habitats and legally protected and notable species. As part of the Project's DCO application, an OLEMS will be submitted which will set out the ecological mitigation requirements identified within the ES that must be incorporated into the EMP for delivery during the Project's construction.
All receptors (best practice)	The EMP will include details of best practice for minimising impact to notable habitats and legally protected and notable species, including (but not limited to): • Ensuring best practice pollution prevention measures are adhered to at all times to minimise the risk of pollutant release to sensitive habitats (see Chapter 21 Water Resources and Flood Risk, Volume I). • BPM to be employed during construction to limit dust, odour, and exhaust emissions during construction works, to reduce potential effects upon air quality-sensitive habitat (see Chapter 20 Onshore Air Quality, Volume I). • All habitats temporarily disturbed during constricted are reinstated in full upon completion of construction.
Mitigation by site selection	The onshore project area and onshore substation zone have been defined following an extensive site selection process, which has sought to take account of environmental, engineering, planning and land requirements to seek to identify the most sensitive project location. The site selection process is described in detail in Chapter 4 Site Selection and Assessment of Alternatives, Volume I. The site selection process has included consideration of the following ecological criteria as part of the process: • Avoidance of European sites and associated buffer zones for indirect effects, as far as possible;

Parameter	Mitigation measures embedded into North Falls design
	• Avoidance of habitat potentially suitable for supporting legally protected and notable species as far as possible. As part of this process, the onshore project area presented in PEIR Chapter 5 Project Description (Volume I) does not overlap with an European site for nature conservation.
Mitigation by construction method selection	North Falls has committed to seeking to use trenchless techniques (e.g. HDD) where possible at all key sensitive linear features, including the following relevant to the RIAA: • Land within Holland Haven Marshes SSSI; • Holland Brook and associated watercourses at landfall; • Watercourses upstream of Hamford Water SAC. At this stage in the Project's design, trenchless techniques cannot be committed to at all locations, where the engineering feasibility of using such techniques needs further assessment before it can be confirmed. The list of techniques being considered at each crossing is described in PEIR Chapter 5 Project Description (Volume I), Appendix 5.1 Crossing Schedule (Volume III).
	At all trenched watercourse crossings, best practice measures will be in place to minimise disturbance of the beds, banks and downstream habitats (see PEIR Chapter 21 Water Resources and Flood Risk, Volume I): The amount of time that any temporary dams are in place will be kept to a minimum; Prior to dewatering the area between any temporary dams, a fish rescue would be undertaken; Flumes or pumps would be adequately sized to ensure that flows downstream are maintained whilst minimising upstream impoundment; Scour protection would also be used to protect the river bed downstream of the dam from high energy flow at the outlets of flumes and pumps; and Sympathetic reinstatement of channel and banks.
HDD	As advised by Natural England during the EPP, an Outline HDD Method and Draft 'Break-out' Contingency Plan will be submitted with the Project's DCO application to provide assurance that reasonable steps will be taken to minimise the risk of effects arising as a result of 'break-out' during HDD beneath watercourses.
Habitat reinstatement	As noted above, where practicable all habitats subject to temporary disturbance during construction, will be reinstated in full following the completion of construction. The specific details of the reinstatement will be set out within the EMP for each habitat. The following core principles for habitat reinstatement would be included within the EMP relevant to the RIAA: • Grassland habitats • Arable field margins • • Grassland habitats All topsoil stripped in grassland areas would be stored separately and reinstated following the completion of construction. Topsoil storage would be subject to a Soil Management Plan, which would also detail measures for soil storage and handling. Grassland reseeding (excluding land under arable rotation) would be undertaken using a local seed mix, to be agreed in advance with Natural England and Essex Wildlife Trust. Arable field margins If landowner permission can be reached, this habitat will be reinstated in consultation with Essex Wildlife Trust and the local landowner to ensure the optimum benefits can be gained from each margin affected. Prior to construction, the arable field margins will be re-surveyed to assess their conservation value. Attempts will then be made to ensure habitat reinstatement takes the form of one of the following (JNCC, 2008): Cultivated, low-input margins (land managed specifically to create habitat for annual arable plants); Margins sown to provide seed for wild birds (margins or blocks sown with plants that are allowed to set seed and which remain in place over the winter); Margins sown with wild flowers or agricultural legumes and managed to allow flowering to provide pollen and nectar resources for invertebrates;

Parameter	Mitigation measures embedded into North Falls design
	Margins providing permanent, grass strips with mixtures of tussocky and fine-leaved grasses.
Best practice dust management mitigation measures	The Project will commit to the implementation of best practice dust mitigation measures associated with a 'high risk' site, as described by the IAQM guidance (2016). These measures will be outlined within the Project's Outline Code of Construction Practice submitted as part of the Project's DCO application and will be secured within the final Code of Construction Practice submitted post-consent.

9.1.4 Scope of the shadow Appropriate Assessment

1543. The scope of the shadow appropriate assessment for the onshore SAC sites to be considered is based on the screening of designated sites and impacts identified in the HRA Screening Report. The only onshore SAC screened into this assessment is Hamford Water SAC.

1544. The shadow appropriate assessment considers the following impacts, based on those identified in the HRA Screening Report:

- Impact 1: Indirect effects on Annex I habitats and Annex II species from air emissions;
- Impact 2: Indirect disturbance of Annex II species from noise;
- Impact 3: Indirect disturbance of Annex II species from visual/ lighting;
- Impact 4: Indirect effects on Annex I habitats and Annex II species arising from changes in supporting surface or groundwater resources; and
- Impact 5: Direct and indirect effects on ex-situ habitats which support Annex II species of European sites.

1545. With respect to each of these identified impacts, an assessment will be carried out for each designated site's qualifying features, within the context of the site's conservation objectives. The assessment should be read in conjunction with PEIR Chapter 23 Onshore Ecology (Volume I) and PEIR Onshore Ecology Appendices 23.1 to 23.7 (Volume III) which present detailed information on baseline conditions within the onshore project area, and an assessment on impacts to ecological features, including species which are also qualifying features Hamford Water SAC.

9.2 Hamford Water SAC

9.2.1 SAC overview

1546. Hamford Water SAC is a large, shallow estuarine basin within the Greater Thames Estuary National Character Area (NCA) that covers an area of 50.34ha, comprising tidal creeks, islands, intertidal mud, sand flats and saltmarshes. Above the saltmarsh there is unimproved and improved grassland (including grazing marsh), scrub, woodland, hedges, ditches, ponds and reedbeds. The underlying geology consists of Tertiary, Palaeogene clays overlain by Neogene and early Pleistocene crag deposits and fluvial deposits of mud, sand and shingle.

1547. The SAC is designated primarily for the presence of the Annex II species Fisher's estuarine moth *Gortyna borelli lunata* which is only found in two UK locations, the north Essex coast and the north Kent coast.

1548. No other species or habitats are listed as primary reasons or qualifying features of the SAC's designation.

9.2.1.1 Fisher's estuarine moth

9.2.1.1.1 Details of the qualifying feature

1549. The Fisher's estuarine moth is a EPS listed on Annex II of the Habitats Directive (92/43/EEC) and implemented in the UK by the Conservation of Habitats and Species Regulations 2017 (as amended). Additionally, the Fisher's estuarine moth is also a Red Data Book listed species.

1550. There is no known or predicted figure for the current population of Fisher's estuarine moth in the UK. However, of the ten UK occurrence records for the moth species available on the National Biodiversity Network (NBN) Atlas, seven are situated within Hamford Water SAC (NBN Atlas Partnership 2021a). These records date from 1973 – 2014 so are unlikely to accurately represent the current population in the SAC.

1551. The site is described in the SAC citation as follows:

"Hamford Water supports the majority of the Essex population and is the most important UK site for this species, supporting approximately 70% of the population. Hamford Water is a large, shallow estuarine basin comprising tidal creeks, islands, intertidal mud, sand flats and saltmarshes. Above the saltmarsh there is unimproved and improved grassland (including grazing marsh), scrub, woodland, hedges, ditches, ponds and reedbeds. The site encompasses those areas where the moth's food plant hog's fennel (Peucedanum officinale) grows and where there is an abundance of the grasses required by the species for egg laying." (JNCC, 2016).

1552. The moth's eggs hatch in late spring, where larvae then feed on hog's fennel stems and roots before pupating, with adults finally emerging in autumn (Butterfly Conservation, 2023). Larvae of Fisher's estuarine moth are therefore dependent on their sole food plant, hog's fennel *(Peucedanum officinale)*, which also has a very limited distribution and is at risk from sea-level rise as well as historic poor habitat management (Ringwood, Hill and Gibson, 2004). Hog's fennel, even though it is a coastal species, cannot tolerate saltwater so is more closely associated with sea walls and coastal grasslands (Butterfly Conservation, 2023). Coastal grasses such as sea couch *Elymus pungens* and false oat-grass *Arrhenatherum elatius* that often surround hog's fennel are utilised by Fisher's estuarine moth for oviposition and are also essential for their breeding success. Without such coarse grass species, oviposition is not possible (Ringwood, Hill and Gibson, 2002).

1553. Of the 42 occurrence records for hog's fennel in the UK available on the NBN Atlas, seven are situated within Hamford Water SAC dated from 2016 - 2019 (NBN Atlas Partnership, 2021b).

1554. In 2006, a project was set up to plant a sustainable landscape-scale network of Hog's fennel sites and habitat suitable for Fisher's estuarine moth on the Essex coast (Action for the Wild, 2022). The creation of habitat has, to date, has involved planting 32 sites along the Essex coastline. Habitat creation has been combined with captive breeding of Fisher's estuarine moth at Colchester Zoo since 2008, establishing new wild populations of the species with positive records of larval feeding in 20 out of the 27 areas studied (Action for the Wild, 2022; Gardiner *et al.*, 2016). The success of reintroducing this moth species is underpinned by connectivity, quality and density of wild hog's fennel, therefore any works which adversely impact hogs' fennel will in turn indirectly impact Fisher's estuarine moth. Coarse grasses for moth oviposition have not required habitat management intervention due to being relatively common species.

1555. The Essex Biodiversity Action Plan (BAP) (1999) states that the current factors causing loss or decline of Fisher's estuarine moth in Essex are:

- Unsympathetic mowing regimes on the sea walls, on which a large proportion of the food plant is found;
- Sea-level rise, adversely affecting food plants outside the sea wall, and necessitating structural improvements to or realignment of sea walls;
- Scrub encroachment onto some major colonies of hog's fennel; and
- Collection of specimens, as adults or large larvae, the latter through illegal uprooting of the food plant.

1556. Current actions relating to the conservation of the moth listed in the Essex BAP include:

- The moth being monitored informally each year over parts of its range by the Essex Lepidoptera Panel;
- Local adjustments to the Environment Agency mowing regime have been initiated to cater for the needs of the moth;
- Scrub control around core areas for the food plant;
- JNCC, with support of Natural England, Essex Wildlife Trust and Essex Lepidoptera Panel, have recommended to the Government that the moth should be given statutory protection against collection; and
- The majority of the moth and food plant population is located within a SSSI, SPA and Ramsar site, much of it within an NNR. This now includes Hamford Water SAC.

1557. The Essex BAP action plan objectives and proposed targets in regard to the Fisher's estuarine moth are:

- To ensure that the present distribution and abundance of the hog's fennel are at least maintained, and that the core populations still support the moth;
- To maintain and develop monitoring programmes, to achieve a clearer understanding of population dynamics and trends;
- To ensure that the needs of both moth and food plant are addressed in any future sea wall works, both capital and maintenance, around the Walton Backwaters; and
- To eliminate unauthorised and commercial collection of larvae and adults.

9.2.1.1.2 Status of the qualifying feature within the onshore project area and adjacent habitats

1558. Hamford Water SAC is situated 0.28km northeast of the onshore project area at its closest point, near Beaumont Cut.

1559. Records of hog's fennel within Hamford Water SAC are associated with coastal grassland habitats, typically being found adjacent to areas of sea wall, or on the landward side of the coastal zone adjacent to upper saltmarsh (Natural England, 2019). These habitats are not found within the onshore project area. Similarly, Fisher's estuarine moth records are located entirely within the footprints of the SAC (NBN Atlas, 2021b).

1560. Hog's fennel was recorded within the bounds of Holland Haven Marshes SSSI in *Lolium perenne – Alopecurus pratensis – Festuca pratensis* grassland (NVC code MG7c) in the National Vegetation Classification (NVC) survey undertaken 2021. In this grassland type, coarse grasses required by the species for egg laying would be fairly common. Holland Haven Marshes SSSI is within the onshore project area and all land within the SSSI boundary is being avoided through the use of HDD techniques to install cable ducts in this area. Full details of the NVC survey are outlined in PEIR Onshore Ecology Appendix 23.7 (Volume III).

1561. Due to the strong association between Fisher's estuarine moth and its host plant, there is the potential that moth populations could be utilising the hog's fennel found within the onshore project area. This has since been confirmed by a terrestrial and aquatic invertebrate survey undertaken in 2021, which reports known records (obtained from a data search from Essex Field Club) of the moth species within Holland Haven Marshes SSSI and the onshore project area. This population is potentially isolated from the Hamford Water SAC moth population, however, is still of national notable importance. Full details of the invertebrate survey are outlined in PEIR Onshore Ecology Appendix 23.6 (Volume III).

1562. Generally, moth home ranges and dispersal rates vary between species and are highly dependent on wind speed and species-specific habitat resource availability (Alerstam *et al*., 2011). Due to the coastal location increasing exposure and the specificity of larval feeding behaviour, it is likely Holland Haven Marshes SSSI and Hamford Water SAC populations of Fisher's estuarine moth are isolated and do not mix while breeding or feeding. Distinctly separate populations of Fisher's estuarine moth have been recorded between the mainland and Skippers Island within Hamford Water SAC, which are approximately 1.7km apart (Gardiner and Ringwood, 2010). Hamford Water SAC is approximately 5.7km north of Holland Haven Marshes SSSI, therefore moth population mixing is unlikely due to the geographical distance of these two sites.

9.2.2 Conservation objectives

1563. The conservation objectives identified for Hamford Water SAC, as detailed by Natural England (2019d), include maintaining or restoring:

- The extent and distribution of the habitats of qualifying species;
- The structure and function of the habitats of qualifying species;

- The supporting processes on which the habitats of qualifying species rely;
- The populations of qualifying species; and
- The distribution of qualifying species within the site.

1564. The implementation of these conservation objectives will ensure that the integrity of the site is maintained or restored as appropriate and ensure that the site contributes to achieving the FCS of its Qualifying Features (i.e., Fisher's estuarine moth).

9.2.3 Shadow Appropriate Assessment

1565. The only qualifying feature of Hamford Water SAC and therefore the only feature to be considered in this assessment is the Fisher's estuarine moth.

1566. The Fisher's estuarine moth's dispersal is dependent on the presence of its larval food plant, hog's fennel, as well as coarse grass species required for oviposition. As hog's fennel is present within the onshore project area (specifically in Holland Haven Marshes SSSI) as well as historic records of the moth species in the area, it is assumed for this assessment that the Fisher's estuarine moth is also present within the onshore project area within Holland Haven Marshes SSSI. However, it is unlikely that the population of Fisher's estuarine moth present within the onshore project area is linked to or a component of the moth population at Hamford Water SAC, mainly due to geographical isolation.

1567. The Holland Haven Marshes SSSI population of Fisher's estuarine moth is included in this assessment as it forms part of the local habitat network which provides some resilience to the population found within the Hamford Water SAC.

9.2.3.1 Impact 1: Indirect effects on Annex I habitats and Annex II species from air emissions

1568. There is limited evidence as to the effects of noise pollution on moths, other than a limited potential for noise and dust to affect moth physiology, behaviour, and reproduction (Newport, Shorthouse and Manning, 2014; Van Dongen, Lens and Matthysen, 2001).

1569. Potential effects arising from dust emissions during the Project construction, which have the potential to lead to temporary localised, short term effects on tidal flora such as hog's fennel and coarse grasses (e.g., on their photosynthesis functioning) however any such effects are limited to the extreme short term (i.e., until washed away), and any nutrient effects from dust on coastal grassland habitats in which Hog's fennel is located are minimal. Embedded mitigation to manage dust emissions is set out in Table 9.2 will also reduce the release of dust down to a level identified as non-significant within that Chapter.

1570. As a result of embedded mitigation, no indirect effects arising from air emissions will impact Annex II species such as the Fisher's estuarine moth, and no AEoI is therefore predicted.

9.2.3.2 Impact 2: Indirect disturbance of Annex II species from noise.

1571. As noted above, there is limited evidence as to the effects of noise pollution on moths, other than a limited potential for noise and dust to affect moth physiology, behaviour, and reproduction (Newport, Shorthouse and Manning, 2014; Van Dongen, Lens and Matthysen, 2001).

1572. Hamford Water SAC is located within the precautionary Zone of Influence (ZoI) of 500m for noise disturbance, identified in the HRA Screening Report (Appendix 1), however there is no clear link indicating that either Fisher's estuarine moth nor the habitat which supports it will be at risk from disturbance form noise generating activities. Therefore, will be no effects on Fisher's estuarine moth or their habitat within Hamford Water SAC due to noise.

1573. It should be also noted that, any excess noise produced by the Project during construction will be localised and temporary in nature. More detail into noise associated with construction is set out in PEIR Chapter 26 Noise and Vibration, Volume I.

1574. As a result of impacts being localised and temporary, no indirect effects arising from noise disturbance will impact Annex II species such as the Fisher's estuarine moth, and no AEoI is therefore predicted.

9.2.3.3 Impact 3: Indirect disturbance of Annex II species from visual/ lighting

1575. As the Annex II Fisher's estuarine moth is a nocturnal species, artificial light at night has the potential to impact moths during construction.

1576. Excessive exposure to artificial light can cause life cycle changes in moths, specifically larvae entering pupation too early, and larvae emerging from pupation much earlier than larvae which were not exposed to artificial light (Van Geffen *et al.,* 2014). Artificial light reducing the overall larval pupation period may result in reduced fitness and increased mortality.

1577. Artificial light at night has also been found to inhibit breeding behaviour in moth species. Female moths found in areas with artificial light at night have been found to have reduced breeding rates than those in non-illuminated areas (Van Geffen et al., 2015). Furthermore, male moths in areas with artificial light have shown reduced attraction to female moth pheromone traps, which can in turn show reduced attraction to female moths when exposed to artificial light at night (Van Geffen *et al.,* 2015).

1578. Outside of breeding, artificial light at night also impacts moth species interactions, including intra-specific communication, trophic interactions and plant–pollinator interactions, with cascading effects in the ecosystem and impacts on ecosystem functioning (Grubisic and Van Grunsven, 2021). Reduced population sizes and changes in invertebrate community composition because of exposure to artificial light at night have been reported, but the understanding of the impacts is still very limited in scientific literature.

1579. As part of the embedded mitigation set out in PEIR Chapter 23 Onshore Ecology (Volume I), security lighting used during construction adheres as far as possible to accepted lighting guidance (BCT and ILP, 2018). This includes the following measures:

- Ensure security lighting is cowled and angled downwards and does not shine directly on sensitive habitats; and
- Ensure security lighting is motion activated to minimise unnecessary lighting.

1580. By employing sensitive lighting measures within the onshore project area during construction, artificial light at night will be localised to zones and habitats which are not of value to the Annex II Fisher's estuarine moth i.e. those located at approximately 300m from the boundary of the SAC, and at least from 50m from any of the records reported during the 2021 Invertebrate Survey at Holland Haven Marshes SSSI (PEIR Onshore Ecology Appendix 23.6 (Volume III)). Therefore, it is unlikely that the above adverse effects artificial lighting can have on moths will occur. If light spill does occur into valuable areas for the moth species, this disturbance will be temporary and will not have a long-term adverse effect on local populations and their dynamics.

1581. Additionally, operational lighting will be localised to the area surrounding the onshore substation, which does not contain suitable habitat for Fisher's estuarine moth.

1582. As a result of impacts being localised and temporary and the mitigation proposed, no indirect effects arising from light and visual disturbance will impact Annex II species such as the Fisher's estuarine moth, and no AEoI is therefore predicted.

9.2.3.4 Impact 4: Indirect effects on Annex I habitats and Annex II species arising from changes in supporting surface or groundwater resources

1583. There are potential effects arising from increases in sediment/ potential pollutant release during installation of cable ducts across watercourses located approximately 300m upstream of the Hamford Water SAC. As part of the Project's embedded mitigation, the watercourses which feed Hamford Water are proposed to be crossed using trenchless techniques (HDD) to minimise the risks of any downstream effects. As such the only effects which may arise will be in the event of 'break-out' i.e. when drilling fluid (an inert clay) is accidentally released into the watercourse. The development and implementation of a breakout management plan, as outlined in Section 8.1.3, will mitigate potential effects and reduce the risk should a break-out occur. The plan will include measures to trap and remove the clay before it is released downstream.

1584. The trenching works and trenchless works located within the catchment will not extend greater than 2m below ground level for trenching works or 5m below ground level for trenchless duct installation. As such the interaction with ground water resources minimal, and connectivity with the ground water resources which support Hamford Water are not anticipated.

1585. As a result of embedded mitigation, no indirect effects arising from changes in supporting surface or groundwater resources will impact Annex II species such as the Fisher's estuarine moth, and no AEoI is therefore predicted.

9.2.3.5 Impact 5: Direct and indirect effects on ex-situ habitats which support Annex II species of European sites.

1586. As established in the terrestrial and aquatic invertebrate survey undertaken in 2021 (PEIR Onshore Ecology Appendix 23.6 (Volume III)), it is highly likely that Fisher's estuarine moth are present within the Holland Haven Marshes SSSI. Holland Haven Marshes SSSI has habitat suitable for both larval feeding and oviposition by the Fisher's estuarine moth, specifically with the presence of hog's fennel and coarse grass species. Areas outside of the SSSI in the onshore project area do not have recorded hog's fennel and therefore lack habitat suitable for the moth species.

1587. North Falls has committed to using HDD techniques to avoid direct impacts on land within the SSSI. Using HDD would therefore avoid destruction of the moth's habitat, larvae, eggs, and adult populations within the onshore project area at Holland Haven Marshes SSSI. Furthermore, Hog's fennel and the coarse grass species which support the moth are terrestrial species and are not at risk in the unlikely event of a breakout during the HDD process.

1588. By committing to HDD at this section of the onshore project area, no indirect effects on ex-situ habitats which support Annex II Fisher's estuarine moth will occur, and no AEoI is therefore predicted.

9.3 In-combination effects

9.3.1 In-combination construction effects

9.3.1.1 Five Estuaries

1589. The overlapping nature of both North Falls and Five Estuaries OWF onshore project areas means that the Five Estuaries construction activities will very likely also affect Holland Haven Marshes SSSI, which has resident Fisher's estuarine moth.

1590. In the Five Estuaries Scoping Report, there is a commitment to using trenchless techniques at landfall, crossing Holland Haven Marshes SSSI. The potential for cumulative effects on Fisher's estuarine moth within the onshore project area are therefore considered to be limited if there is also temporal overlap in construction activities. North Falls is planned for construction from 2026 at the earliest, compared to 2028 to 2030 for Five Estuaries and so sequential construction may occur. However, this is unlikely to change the overall likelihood of adverse effects on Fisher's estuarine moth.

1591. As noted above, in-combination effects during the Projects' operation have not been screened in for further assessment.

1592. No other projects have been identified that potentially impact the habitat of Fisher's estuarine moth.

9.4 Overall Conclusion

1593. The evidence presented above indicates that, when taking into consideration mitigation, no adverse effect on the integrity of the Hamford Water SAC will occur due to the project either alone or in-combination with other projects.

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