Hornsea Project Three
Offshore Wind Farm

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Habitats Regulations Assessment
Report to Inform Appropriate Assessment

PINS Document Reference: A5.2
APFP Regulation 5(2)(g)

Date: May 2018

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Report Number: A5.2

Version: Final

Date: May 2018

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Front cover picture: Kite surfer near a UK offshore wind farm © Orsted Hornsea Project Three (UK) Ltd., 2018.

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Glossary

Term	Definition
Application for Development Consent	An application made to the Secretary of State under the Planning Act 2008 for development consent for one or more Nationally Significant Infrastructure Projects (NSIP)
Appropriate Assessment	An assessment to determine the implications of a plan or project on a European site in view of the site's Conservation Objectives. An AA forms part of the Habitats Regulations Assessment and is required when a plan or project is likely to have a significant effect on a European site.
Annex I Habitat	Natural habitat types of community interest whose conservation requires the designation of Special Areas of Conservation.
Annex II Species	Animal and plant species of community interest whose conservation requires the designation of Special Areas of Conservation.
Barrier Effect	The potential for birds to fly around an array of turbines causing an increase in the overall distance flown than would otherwise have been the case if the wind turbines had not been present.
Birds Directive	Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the Conservation of Wild Birds.
Cable Corridor	The specific corridor of seabed (seaward of MHWS) and land (landward of MHWS) from the Hornsea Project Three array area to the Norwich Main National Grid substation, within which the export cables will be located. The final cable corridor will be located within the cable corridor search area and will be defined via a site selection process considering technical, physical and environmental constraints.
Cable Corridor Search Area	The broad offshore corridor of seabed (seaward of the MHWS) and land (landward of MHWS) from the Hornsea Project Three array area to the Norwich Main National Grid substation considered within this Scoping Report, within which the refined cable corridor will be located.
Collision risk	Potential number of birds at risk of collision from a wind farm.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Project Three.
Decommissioning Plan	A document confirming the geographic scope/spatial extent of decommissioning activities, process for seeking approval for decommissioning, and standards/objectives for the decommissioning process. A Decommissioning Plan is to be referred to for all decommissioning activities landward of Mean High Water Springs.
Decommissioning Programme	A document confirming the geographic scope/spatial extent of decommissioning activities, process for seeking approval for decommissioning, and standards/objectives for the decommissioning process. A Decommissioning Programme is to be referred to for all decommissioning activities seaward of Mean High Water Springs.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Three design options under consideration, as set out in detail in the project description. This envelope is used to define Hornsea Project Three for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).

Term	Definition
Displacement	The potential for birds and other animals to avoid an area due to the presence of the wind turbines or from vessel activity.
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Emergency Response and Cooperation Plan (ERCoP)	A document detailing the emergency co-operation plans for the construction, operation and decommissioning phases of Hornsea Project Three.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Impact Assessment (EIA) Report.
European site	A Special Area of Conservation (SAC) or candidate SAC (cSAC), a Special Protection Area (SPA) or potential SPA (pSPA), a site listed as a site of community importance (SCI) or a Ramsar site.
Former Hornsea Zone	The Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by The Crown Estate (TCE) during its third round of offshore wind licensing. In March 2016, the Hornsea Zone Development Agreement was terminated and project specific agreements, Agreement for Leases (AfLs), were agreed with The Crown Estate for Hornsea Project One, Hornsea Project Two, Hornsea Project Three and Hornsea Project Four. The Hornsea Zone has therefore been dissolved and is referred to throughout the Hornsea Project Three Scoping Report as the former Hornsea Zone.
Habitats Regulations Assessment (HRA)	A process which helps determine Likely Significant Effects and (where appropriate) assesses adverse effect on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI).
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Hornsea Project One	The first offshore wind farm project within the former Hornsea Zone. It has a maximum capacity of 1.2 gigawatts (GW) or 1,200 MW and includes all necessary offshore and onshore infrastructure required to connect to the existing National Grid substation located at North Killingholme, North Lincolnshire. Referred to as Project One throughout the RIAA.
Hornsea Project Three	The third offshore wind farm project within the former Hornsea Zone. It includes offshore and onshore infrastructure to connect to the existing National Grid substation located at Norwich Main, Norfolk. Referred to as Hornsea Three throughout the RIAA.
Hornsea Project Two	The second offshore wind farm project within the former Hornsea Zone. It has a maximum capacity of 1.8 GW (1,800 MW) and includes offshore and onshore infrastructure to connect to the existing National Grid substation located at North Killingholme, North Lincolnshire. Referred to as Project Two throughout the RIAA.
Impact	Change that is caused by an action; for example, land clearing (action) during construction which results in habitat loss (impact).
In-combination assessment	The combined effect of Hornsea Project Three in combination with the effects from a number of different projects, on the same single feature.

Term	Definition
Landfall Area	The area between Mean High Water Springs and Mean Low Water Springs in which all of the export cables will be landed and is the transitional area between the offshore export cabling and the onshore export cabling.
Magnitude	A combination of the extent, duration, frequency and reversibility of an impact.
Marine Mammal Mitigation Protocol (MMMP)	A document detailing the protocol to be implemented in the event that driven or part-driven pile foundations are proposed to be used. The protocol identifies the methods for detection, potential mitigation and monitoring/reporting protocols for marine mammals.
Marine Pollution Contingency Plan (MPCP)	A document addressing the risks, methods and procedures to deal with spills and collusion incidents during the construction, and operation and maintenance phase.
Mean High Water Spring (MHWS)	The height of mean high water during spring tides in a year.
Mean Low Water Spring (MLWS)	The height of mean low water during spring tides in a year.
Norwich Main National Grid Substation	The existing National Grid Norwich Main substation which Hornsea Project Three will ultimately connect to.
Offshore Habitats Regulations	The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended), which applies to marine habitats extending beyond 12 nautical miles (NM).
Planning Inspectorate (PINS)	The executive agency of the Department for Communities and Local Government responsible for operating the planning process for NSIPs.
Preliminary Environmental Information (PEI) Report (PEIR)	Defined in the EIA Regulations as information referred to in Part 1 of Schedule 4 information for inclusion in environmental statements which - (a) has been compiled by the applicant; and (b) reasonably required to assess the environmental effects of the development (and of any associated development)
Project Description	A summary of the engineering design elements of Hornsea Project Three.
Project Environmental Management and Monitoring Plan (PEMMP)	In conjunction with the MPCP, this plan provides environmental risk analysis covering waste management, offshore maintenance plans, details of Archaeological Exclusion Zones (AEZ), seasonal and working restrictions, and protocol for the appointment of Fisheries and Environmental Liaison Officers.
Ramsar Convention	The Convention on Wetlands of International Importance especially as Waterfowl Habitat which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
Ramsar Site	Wetlands of international importance, designated under the Ramsar Convention.
Sites of Community Importance	Sites that have been adopted by the European Commission in accordance with the Habitats Directives but not yet formally designated by the government of each country
Scour Protection Management Plan (SPMP)	A document detailing the need, type, sources, quantity, location and installation methods for scour protection and cable armouring.
Sensitivity	The extent to which a receptor can accept a change, of a particular type and scale.
Significance	The significance of an effect combines the evaluation of the magnitude of an impact and the sensitivity of the receptor.
Special Area of Conservation	Strictly protected sites designated under Article 3 of the Habitats Directive for habitats listed on Annex I and Animals listed on Annex II of the Directive.
Special Protected Area	Strictly protected sites designated under Article 4 of the Birds Directive for species listed on Annex I of the Directive and for regularly occurring migratory species.
Suspended sediments	Particulates in suspension in the water column, often comprising fine material such as clays and silts.
Transboundary	Crossing into other European Economic Association (EEA) States.

Acronyms

Acronym	Full Terminology
AA	Appropriate Assessment
BDMPS	Biologically Defined Minimum Population Scale
BEIS	Business, Energy and Industrial Strategy
Cefas	Centre for Environment Fisheries and Aquaculture Science
CEA	Cumulative Effect Assessment
CO(s)	Conservation Objectives
cSAC	Candidate SAC
DCO	Development Consent Order
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
DML	Deemed Marine Licence
DP	Dynamic positioning
EEA	European Environment Agency
EMF	Electromagnetic Field
FCS	Favourable Conservation Status
GBF	Gravity base foundation
HDD	Horizontal Directional Drilling or other trenchless drill methods
HRA	Habitats Regulations Assessment
HSE MS	Health, Safety and Environmental Management System
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee

Acronym	Full Terminology
LAeq,T	See "Equivalent continuous sound pressure level".
LAmax	See "Maximum sound level"
LAT	Latitude
LA90	LA90 See "Background noise level".
LSE	Likely Significant effect
LWT	Lincolnshire Wildlife Trust
MM EWG	Marine Mammal Expert Working Group
MFE	Mass Flow Excavator
MMO	Marine Management Organisation
NID	National Infrastructure Directorate
OAP	Offshore Accommodation Platform
PEMMP	Project Environmental and Monitoring Plan
PINS	Planning Inspectorate
PRoW	Public Right of Way
pSCI	Proposed Site of Community Importance
pSPA	Potential SPA
PTS	Permanent Threshold Shift
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SCI	Site of Community Importance
SEL	Sound Exposure Level
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SoS	Secretary of State
TCE	The Crown Estate
TJB	Transition Joint Bay
TTS	Temporary Threshold Shift
TWT	The Wildlife Trust
VOR	Valued Ornithological Receptor
VSC	Voltage Source Converter
WTG	Wind Turbine Generator
ZDA	Zone Development Agreement
ZEA	Zone Environmental Appraisal
ZoI	Zone of Influence

Units

Acronym	Full Terminology
GW	Gigawatt
kJ	Kilojoule
km	Kilometre
kV	Kilovolt
kW	Kilowatt
MW	Megawatt

1. Executive Summary

1.1 Introduction

1.1.1.1 Wherever a project that is not directly connected to, or necessary for the management of a European Site is likely to have a significant effect on the Conservation Objectives (COs) of the site (directly, indirectly, alone or in-combination with other plans or projects) then an 'Appropriate Assessment' (AA) must be undertaken by the Competent Authority (Regulation 63 of the Habitats Regulations[1] and Regulation 28 of the Offshore Habitats Regulations[2]). The AA must be carried out before consent or authorisation can be given for the project.

1.1.1.2 This Report to Inform Appropriate Assessment (RIAA) has been produced to inform the Habitat Regulations Assessment (HRA) process for the Hornsea Project Three Offshore Wind Farm (hereafter referred to as Hornsea Three).

1.1.1.3 It provides information to allow the Secretary of State (as the Competent Authority) to determine whether there will be an adverse effect on the integrity of any European Site(s) in view of their COs as a result of the project.

1.1.1.4 For the purpose of this report European Sites are defined as Special Areas of Conservation (SACs), Sites of Community Importance (SCIs), Candidate SACs (cSACs) and possible SACs (pSACs) designated under the Habitats Directive (92/43/EEC) and Special Protection Areas (SPAs), including potential SPAs (pSPA), designated under Council Directive (2009/147/EC) on the Conservation of Wild Birds (the 'Birds Directive'). In addition to sites designated under European nature conservation legislation, UK Government policy (ODPM Circular 06/2005) states that internationally important wetlands designated under the Ramsar Convention 1971 (Ramsar sites and potential Ramsar sites) are afforded the same protection as SPAs and SACs, for the purpose of considering development proposals that may affect them and so are considered in this report as "European Sites".

1.1.1.5 It should be noted that this report is focused on the assessment of potential effects of Hornsea Three on site integrity and should be read in conjunction with the HRA Screening Report (Annex 1) and the Hornsea Three Environmental Statement (Environmental Statement) and associated technical annexes.

1.1.1.6 The RIAA has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2017) and is submitted in support of the Application for Development Consent.

[1] The Conservation of Habitats and Species Regulations 2017
[2] The Conservation of Offshore Marine Habitats and Species Regulations 2017

1.2 HRA Screening

1.2.1.1 The initial stage of the HRA process is to identify the Likely Significant Effects (LSE) arising from Hornsea Three. The approach to screening is described in full in Annex 1: HRA Screening Report.

1.2.1.2 The criteria used in screening for European Sites took account of the location of the sites relative to Hornsea Three, the Zone of Influence (ZoI) of potential impacts potentially arising from the project and the ecology and distribution of qualifying features.

1.2.1.3 The HRA Screening Report initially identified 17 European Sites for which an LSE on one or more features could not be discounted. This list was further refined through consultation with Statutory Nature Conservation Bodies (SNCBs) and other organisations, such as The Wildlife Trust (TWT) and the Royal Society for the Protection of Birds (RSPB).

1.3 Information for Appropriate Assessment

1.3.1 Assessment Methodology

1.3.1.1 The design scenarios selected for assessment of potential impacts on European Sites were those which would result in the greatest potential for significant effect(s) on the relevant qualifying features. These were defined taking account of the information provided in the project description and relevant project designed-in mitigation measures, and are consistent with those used for the Environmental Statement.

1.3.1.2 The in-combination assessment is undertaken, taking account of the Cumulative Effect Assessment (CEA) methodology Screening Exercise used in the Environmental Statement for relevant topics and follows a tiered approach.

1.3.2 Assessment of Adverse Effects on Site Integrity

Benthic Annex I habitats

1.3.2.1 The HRA Screening Report (Annex 1) identified the potential for an LSE on the following European Sites designated for benthic Annex I habitats (features occuring seaward of Mean High Water Springs (MHWS)):

- North Norfolk Sandbanks and Saturn Reef SAC.
- The Wash and North Norfolk Coast SAC

1.3.2.2 The potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects have been assessed with respect to the Conservation Objectives of these European Sites. The Annex I habitats that are qualifying features of these SAC's that are screened into assessment comprise:

- Sandbanks which are slightly covered by seawater all the time; and

- Reefs.

1.3.2.3 With respect to the Conservation Objectives, there is no indication that Hornsea Three, alone or in-combination with other plans and projects would have and adverse effect on the integrity of these European sites (see Section 5).

Annex II marine mammals

1.3.2.4 The HRA Screening Report (Annex 1) identified the potential for an LSE on the following sites designated for Annex II marine mammal species:

- The Wash and North Norfolk Coast SAC;
- Humber Estuary SAC/Ramsar;
- Southern North Sea cSAC;
- Klaverbank SCI (Netherlands);
- Doggersbank SCI (Netherlands); and
- Noordzeekustzone SAC/ Noordzeekustzone II (Netherlands).

1.3.2.5 The potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects have been assessed with respect to the Conservation Objectives of these European Sites. The Annex II marine mammals species that are qualifying features of these European Sites that are screened into assessment comprise:

- Harbour porpoise;
- Harbour seal; and
- Grey seal.

1.3.2.6 With respect to the Conservation Objectives, there is no indication that Hornsea Three, alone or in-combination with other plans and projects would have and adverse effect on the integrity of these sites (see Section 6).

Offshore bird features

1.3.2.7 The HRA Screening Report (Annex 1) and subsequent consultation with SNCBs, identified the potential for an LSE on the following sites designated for offshore birds:

- Greater Wash SPA; and
- Flamborough and Filey Coast (FFC) pSPA / Flamborough Head and Bempton Cliffs SPA.
- Coquet Island SPA
- Farne Islands SPA
- Forth Isalnds SPA

1.3.2.8 The potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects have been assessed with respect to the Conservation Objectives of these European Sites. The offshore species that are qualifying features of these European Sites that are screened into assessment comprise:

- Common scoter;
- Red-throated diver;
- Sandwich tern;
- Fulmar;
- Gannet;
- Puffin;
- Razorbill;
- Guillemot; and
- Kittiwake.

1.3.2.9 With respect to these Conservation Objectives, there is no indication, that the construction and operation of Hornsea Three alone and in-combination with other offshore wind farms will lead to an adverse effect on the qualifying populations of these European sites (see Section 7).

Onshore ecology

1.3.2.10 The HRA Screening Report (Annex 1) identified the potential for an LSE on the following sites designated for onshore ecology:

- Norfolk Valley Fens SAC;
- River Wensum SAC;
- North Norfolk Coast SAC / Ramsar; and
- North Norfolk Coast SPA / Ramsar.

1.3.2.11 The potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects have been assessed with respect to the Conservation Objectives of these European Sites.

1.3.2.12 The Annex I habitats that are qualifying features of these European Sites that are screened into assessment comprise:

- Alkaline fens (Calcium-rich springwater-fed fens);
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) (Alder woodland on floodplains);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (Calcium-rich fen dominated by great fen sedge (saw sedge));
- European dry heath;

- Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) (Purple moor-grass meadows);
- Northern Atlantic wet heaths with *Erica tetralix* (Wet heathland with cross-leaved heath);
- Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) (Dry grasslands and scrublands on chalk or limestone);
- Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; Rivers with floating vegetation often dominated by water-crowfoot
- Coastal lagoons;
- Fixed dunes with herbaceous vegetation (grey dunes). (Dune grassland);
- Embryonic shifting dunes;
- Humid dune slacks;
- Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*). (Mediterranean saltmarsh scrub);
- Perennial vegetation of stony banks. (Coastal shingle vegetation outside the reach of waves); and
- Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes). (Shifting dunes with marram).

1.3.2.13 The Annex II species that are qualifying features of these European Sites that are screened into assessment comprise:

- Narrow-mouthed whorl snail *Vertigo angustior;*
- Desmoulin’s whorl snail *Vertigo moulinsiana;*
- White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes;*
- Brook lamprey *Lampetra planeri;*
- Bullhead *Cottus gobio;*
- Otter *Lutra lutra*; and
- Petalwort *Petalophyllum ralfsii.*

1.3.2.14 The Annex I and migratory bird species that are qualifying features of these European Sites that are screened into assessment comprise:

- Avocet *Recurvirostra avosetta;*
- Bar-tailed Godwit *Limosa lapponica;*
- Bittern *Botaurus stellaris;*
- Dark-bellied Brent Goose *Branta bernicla bernicla;*
- Golden Plover *Pluvialis apricaria;*
- Hen Harrier *Circus cyaneus;*
- Marsh harrier *Circus aeruginosus;*
- Pink-footed Goose *Anser brachyrhynchus;*
- Pintail *Anas acuta;*
- Redshank *Tringa tetanus;*
- Ringed Plover *Charadrius hiaticula;*
- Ruff *Philomachus pugnax; and*
- Wigeon *Anas Penelope.*

1.3.2.15 In addition there is a waterfowl assemblage associated with the North Norfolk Coast SPA that is also screened into assessment.

1.3.2.16 There is no indication, with respect to these Conservation Objectives that Hornsea Three, alone or in-combination with other plans and project, would adversely effect the integrity of these European sites (see Section 8).

2. Introduction

2.1 Hornsea zone

2.1.1.1 The former Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by The Crown Estate (TCE) during its third round of offshore wind licensing. The Hornsea Zone was located in the southern North Sea, approximately 31 km east of the Yorkshire coast and 1 km from the median line between UK and Dutch waters at the closest respective points.

2.1.1.2 As part of a competitive tender, SMart Wind Ltd. (a 50/50 joint venture between International Mainstream Renewable Power (Offshore) Limited and Siemens Project Ventures GmbH; hereafter referred to as SMart Wind) was awarded the rights to the development of the former Hornsea Zone by TCE in 2009. The subsequent Zone Development Agreement between SMart Wind and TCE established a target capacity of 4,000 MW of generating capacity within the former Hornsea Zone, which was to be met through the development of several offshore wind farms.

2.1.1.3 Ørsted A/S (formerly DONG Energy Wind Power A/S) acquired the development rights to Project One in February 2015 and, in August 2015, DONG Energy Power (UK) Ltd. acquired SMart Wind Ltd and the former Hornsea Zone, together with the development rights for Project Two, Hornsea Three and Hornsea Project Four offshore wind farm (hereafter referred to as Hornsea Four). Subsequently in March 2016, the Hornsea Zone Development Agreement was terminated and project specific agreements, Agreement for Leases (AfLs), were agreed with TCE for Project One, Project Two, Hornsea Three and Hornsea Four. The former Hornsea Zone has therefore been dissolved and is referred to throughout the Hornsea Three RIAA (and Annex 1: HRA Screening Report) as the former Hornsea Zone.

2.1.1.4 The first project to be proposed within the former Hornsea Zone was Hornsea Project One. Hornsea Project One comprises up to three offshore wind farms with a maximum generating capacity of 1,218 MW. The Secretary of State granted development consent for Hornsea Project One on 10 December 2014. The second project to be proposed within the former Hornsea Zone was Hornsea Project Two. Hornsea Project Two comprises up to two offshore wind farms with a maximum generating capacity of 1,800 MW. The Secretary of State granted development consent for Project Two on 16 August 2016.

2.1.1.5 The location of the three current offshore wind farm projects within the former Hornsea Zone, and the cable corridor for Hornsea Three are shown in Figure 2.1.

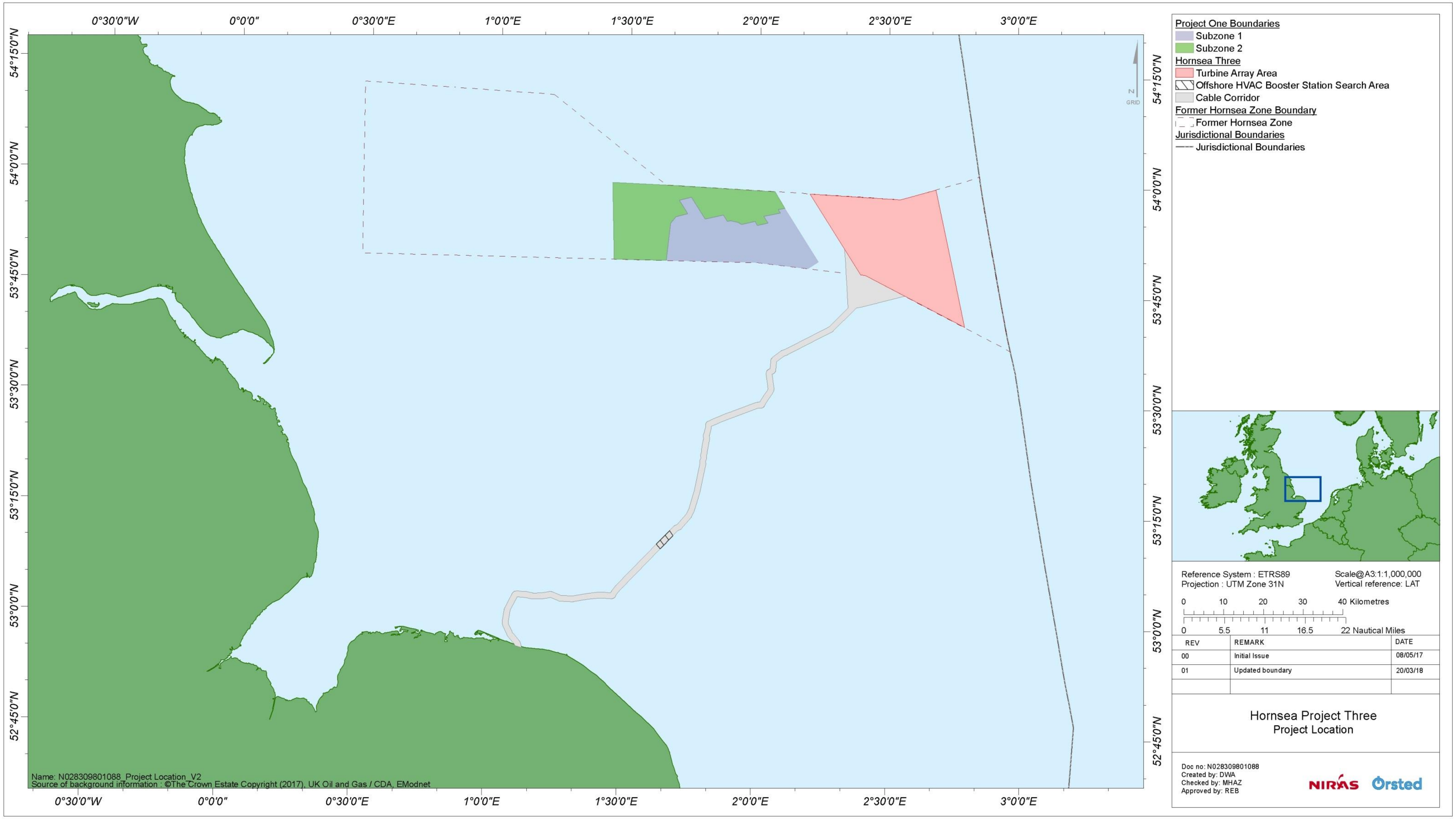


Figure 2.1: Location of the offshore wind farms within the former Hornsea Zone.

2.2 Hornsea Three offshore wind farm

2.2.1.1 Depending upon the size and model of turbine selected, Hornsea Thre will include up to 300 turbines and all infrastructure required to transmit the power generated by the turbines to the existing Norwich Main National Grid substation. The Hornsea Three offshore cable corridor extends from the Norfolk coast, offshore in a north-easterly direction to the western and southern boundary of the Hornsea Three array area. The Hornsea Three offshore cable corridor is approximately 163 km in length.

2.2.1.2 From the Norfolk coast, onshore cables will connect the offshore wind farm to an onshore High Voltage Alternating Current (HVAC) substation/High Voltage Direct Current (HVDC) converter substation, which will in turn, connect to an existing National Grid substation. Hornsea Three will connect to the Norwich Main National Grid substation, located to the south of Norwich. An HVAC booster station (offshore and/or onshore) will be required if a HVAC transmission system is utilised and is located on the cable corridor. The onshore cable corridor is approximately 55 km in length, at its fullest extent.

2.2.1.3 It is proposed that Hornsea Three will have up to 300 turbines. Hornsea Three will also have up to a total of up to 16 offshore substations and up to three Offshore Accommodation Platforms (OAPs) as part of the power transmission system and operation and maintenance set-up, and up to six offshore export cables to transmit power to the national grid. The onshore infrastructure will consist of up to 18 onshore export cables buried in up to six trenches. It may also include an onshore HVAC booster station and will include an onshore HVDC converter/HVAC substation to allow the power to be transferred to the National Grid via the existing Norwich Main National Grid substation.

2.2.1.4 The Hornsea Three boundary, including both onshore and offshore components, was selected following both engineering and environmental considerations (See Environmental Statement volume 1, chapter 4, Site Selection).

Key project components

2.2.1.5 Key project components of Hornsea Three include:

- Turbines;
- Turbine foundations;
- Array cables;
- Offshore substation(s);
- Offshore convertor/transformer substations
- Offshore HVAC booster station
- Offshore accommodation platform(s);
- Offshore export cable(s);
- Onshore cabling; and
- Onshore substation and onshore HVAC booster station.

2.2.1.6 The electricity generated from Hornsea Three will be transmitted via buried High Voltage (HV) cables using either Direct Current (DC) or Alternating Current (AC), or a combination of the two. As a consequence, depending on the option selected prior to construction, Hornsea Three may have some or all of the key components listed above.

2.3 The Habitat Regulations

2.3.1 Legislative context

2.3.1.1 The Habitats Directive (92/43/EEC), on the conservation of natural habitats and of wild fauna and flora, protects habitats and species of European nature conservation importance. Together with Council Directive (2009/147/EC) on the conservation of wild birds (the ‘Birds Directive’), the Habitats Directive establishes a network of internationally important sites, designated for their ecological status. This network of designated sites is comprised of the following:

- SACs are designated under the Habitats Directive and promote the protection of flora, fauna and habitats; and
- SPAs are designated under the Birds Directive in order to protect rare, vulnerable and migratory birds.

2.3.1.2 Terrestrial areas of the UK and territorial waters out to 12 nautical miles (nm) are covered under The Conservation of Habitats and Species Regulations 2017.

2.3.1.3 The Conservation of Offshore Marine Habitats and Species Regulations 2017 transpose the Habitats and Birds Directives into national law, covering waters beyond 12 nautical miles, to the extent of the British Fishery Limits and UK Continental Shelf Designated Area.

2.3.1.4 Combined, The Conservation of Habitats and Species Regulations 2017 and The Conservation of Offshore Marine Habitats and Species Regulations 2017 are herein referred to as the “Habitats Regulations”.

2.3.1.5 Sites going through the formal designation process (i.e. cSAC/pSAC), SCIs and pSPAs are afforded the same level of protection as SACs and SPAs as a matter of Government policy, as are listed and proposed Wetlands of International Importance designated or proposed for their wetland features under the auspices of the Convention of Wetlands of International Importance (commonly referred to as ‘Ramsar sites’) and as such the assessment provisions of the Habitats Regulations are applied to them.

2.3.1.6 For the purpose of this report European Sites are defined as SACs, SCIs[3] and cSACs[4], designated under the Habitats Directive (92/43/EEC), SPAs, including pSPAs, classified under Council Directive (2009/147/EC) on the conservation of wild birds (the 'Birds Directive') and Ramsar sites.

2.3.2 The Habitat Regulations Assessment process

2.3.2.1 The Habitat Regulations require that wherever a project that is not directly connected to, or necessary for the management of a European Site is likely to have a significant effect on the Conservation Objectives of the site (directly, indirectly, alone or in-combination with other plans or projects) then an AA must be undertaken by the Competent Authority (Regulation 63 of the Habitats Regulations and Regulation 28 of the Offshore Habitats Regulations). The AA must be carried out before consent or authorisation can be given for the project[5].

2.3.2.2 The Planning Inspectorate (PINS) Advice note ten 'Habitat Regulations Assessment relevant to nationally significant infrastructure projects' (version 8, November 2017), defines HRA as a step by step process which determines LSE and (where appropriate) assesses adverse effects on the integrity of a European Site, examines alternative solutions, and provides justification of Imperative Reasons of Overriding Public Interest (IROPI). This constitutes a four stage process as summarised below and illustrated in Figure 2.2.

- Stage 1 - Screening: Screening for LSE (alone or in-combination with other projects or plans);
- Stage 2 - Appropriate Assessment: Assessment of implications from identified LSEs on the Conservation Objectives of a European Site to ascertain if the proposal will or will not adversely affect the integrity of a European Site;
- Stage 3 – Assessment of Alternatives to the Project (where it cannot be ascertained that the proposal will not adversely affect the integrity of a European Site); and
- Stage 4 – Assessment of IROPI (where there are no feasible alternative solutions to the project are identified which would have a lesser or would avoid an adverse effect on the integrity of the European Site(s) in question).

2.3.2.3 All four stages of the process are referred to as the "Habitats Regulations Assessment" (HRA) to clearly distinguish the whole process from the one step within it referred to as the "Appropriate Assessment" (AA).

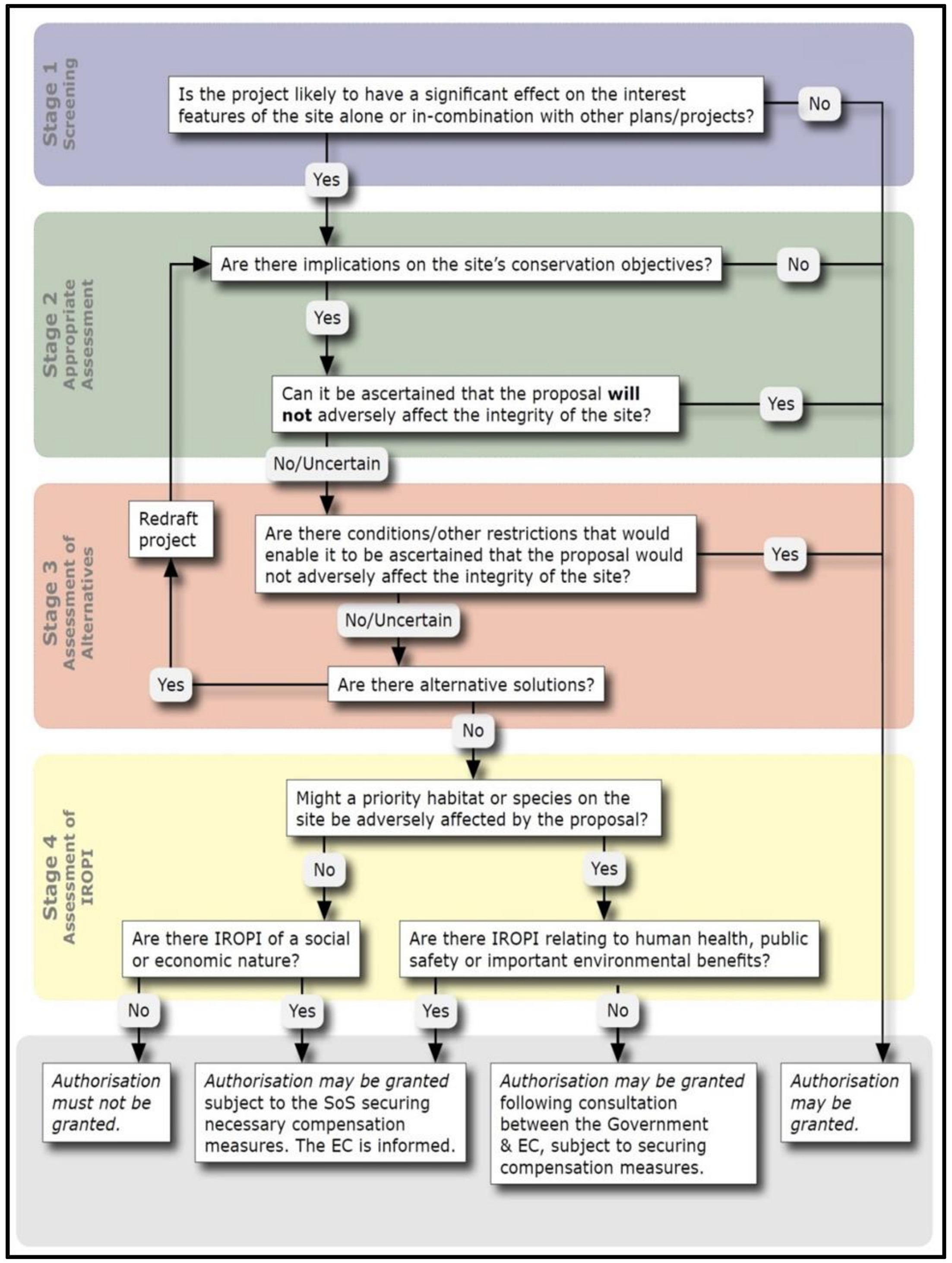


Figure 2.2: Four stage HRA process (The Planning Inspectorate 2016).

[3] Sites of Community Importance (SCIs) are sites that have been adopted by the European Commission but not yet formally designated by the government of each country.

[4] Candidate SACs (cSACs) are sites that have been submitted to the European Commission, but not yet formally adopted.

[5] Regulation 28(8) provides that where a project requires AA under both Habitat Regulations, it is not necessary to do a separate AA for the offshore marine area, provided the AA assesses the effects of the plan or project as a whole for the purposes of both Regulations.

2.3.2.4 The integrity of a site is defined as the coherence of the site's ecological structure and function, across the whole of its area, which enables it to sustain the habitat, complex of habitats and/or populations of species for which the site has been designated (EC, 2001). An adverse effect on integrity is likely to be one which prevents the site from making the same contribution to favourable conservation status as it did at the time of designation.

2.3.3 Roles and responsibilities

2.3.3.1 The National Infrastructure Directorate (NID) within the Planning Inspectorate is the body responsible for processing examining applications for development consent under the Planning Act 2008 on behalf of the Secretary of State. The application for development consent will be examined by a person or a panel appointed by NID (hereafter known as "the Examining Authority"). The Examining Authority will not make the final decision on Hornsea Three; this decision will fall to the Secretary of State for Business, Energy and Industrial Strategy (BEIS) (hereafter referred to as "the Secretary of State").

2.3.3.2 This RIAA produced for Hornsea Three will provide the information required by the Competent Authority to enable it to undertake an AA, in accordance with the Habitats Regulations.

2.3.4 The screening exercise

2.3.4.1 Screening is a relatively coarse filter to identify those sites and features for which a LSE cannot be discounted. The screening exercise undertaken for Hornsea Three was carried out with reference to the English Nature (now Natural England) Guidance Note 3 (HRGN 3) (English Nature, 1999) "The Determination of LSE under the Habitats Regulations", and identified all European Sites that can be associated with Hornsea Three, in terms of connectivity and designated features. Once a site/feature has been identified, the screening exercise considers whether or not a significant effect can be reasonably foreseeable, both directly and indirectly. Where it is not possible to exclude a LSE, then the site is progressed to the AA Stage (Stage 2 of the HRA) in respect of the affected feature(s).

2.3.4.2 The recommended steps in the process for the identification of LSEs as set out in HRGN3 are illustrated in Figure 2.3 and summarised here.

2.3.4.3 In relation to each European Site considered in the screening exercise, at Stage 1 of the HRA process, it will be concluded that either:

- There are no LSEs on the European Site(s), either alone or in-combination with other plans or projects and therefore no further assessment is required; or
- LSEs on the European Site(s) exist or cannot be discounted at this stage, alone or in-combination with other plans or projects, therefore requiring an AA by the competent authority.

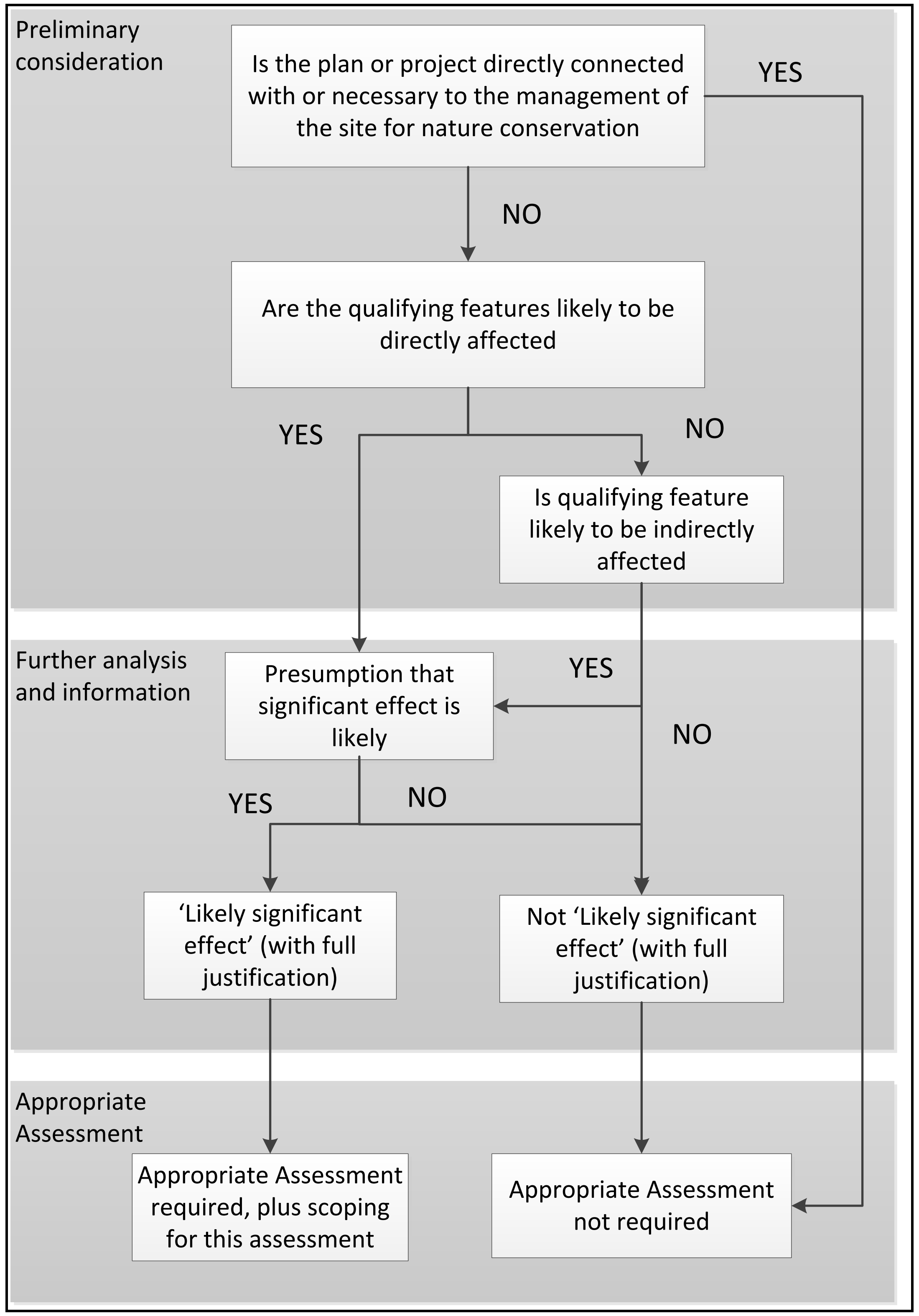


Figure 2.3: Step by step approach to determining LSE on a European Site (adapted from HRGN 3).

2.3.4.4 With respect to in-combination effects, the screening report identified the categories of plans and projects that will considered be within this RIAA. This report includes, for those sites for which LSE could not be excluded, a detailed in-combination assessment drawing on the environmental impact assessment (including cumulative assessment) undertaken specifically for Hornsea Three to determine whether they may lead to an adverse effect on site integrity.

2.3.5 The Appropriate Assessment

2.3.5.1 A European Site is progressed to the AA Stage (Stage 2 of the HRA) where it is not possible to exclude a LSE to one or more qualifying features of that site in view of the Conservation Objectives. European Sites and features which will be subject to an AA for Hornsea Three will therefore be those for which LSEs could not be ruled out during the screening exercise.

2.3.5.2 Undertaking an AA entails consideration of the impacts of a project, alone and in-combination with other plans and projects, on the integrity of a European Site, with regard to the site's structure and function and its Conservation Objectives.

2.3.5.3 The integrity of a site is defined as the coherence of the site's ecological structure and function, across the whole of its area, which enables it to sustain the habitat, complex of habitats and/or populations of species for which the site has been designated (EC, 2001). An adverse effect on integrity is likely to be one which prevents the site from making the same contribution to favourable conservation status as it did at the time of designation. The English Nature (now Natural England) Habitats Regulations Guidance Note 1 (HRGN1) (EN, 1997), describes how an AA should be undertaken. The guidance bases the assessment on a series of nine key steps. These steps include consultation, data collection, impact identification and assessment, recommendation of project modification and/or restriction and reporting.

2.3.6 Purpose of this document and structure

2.3.6.1 This report documents the assessment process undertaken in respect of Hornsea Three, for the purposes of the AA, and provides the information gathered necessary to allow the Secretary of State (as the Competent Authority) to determine whether or not there will be an adverse effect on the integrity of a European Site(s), as a result of Hornsea Three alone or in-combination with other plans and projects.

2.3.6.2 This report should be read in conjunction with the HRA Screening Report (Annex 1) and relevant chapters and technical reports of the Environmental StatementEnvironmental Statement.

2.3.6.3 A full project description is presented within Environmental Statement volume 1, chapter 3 Project Description and is not repeated within this report, however the maximum design senarios pertinent to the assessment presented within this report are provided in Section 4. The project description is indicative and the 'envelope' has been designed to provide sufficient flexibility to accommodate further project refinement during detailed design.

2.3.6.4 This document is structured as follows:

- Summary of screening exercise (Stage 1 of the HRA process; provided in full in Annex 1: HRA Screening Report); and
- Information to inform the AA (Stage 2 of the HRA process), including:
  - Summary of potential impacts of Hornsea Three on relevant features and maximum design scenarios used for assessment and designed-in mitigation measures;
  - Description of the approach taken for in-combination assessment;
  - Review of baseline information on the distribution and ecology of relevant features and European Sites requiring assessment;
  - Assessment of adverse effect on the integrity of European Sites alone by receptor;
  - Assessment of adverse effect on the integrity of European Sites in-combination with other plans and projects by receptor.

3. Screening Exercise for Hornsea Three

3.1 Screening criteria

3.1.1.1 The screening exercise (Stage 1 of the HRA) is presented in full in Annex 1: HRA Screening Report and summarised in the sections below.

3.1.1.2 Following the initial identification of sites, the potential for LSEs was considered. Where there was no potential impact pathway or the potential effects associated with an impact were considered to be insignificant, a site was screened out for further consideration in HRA. Where the potential for LSE could not be excluded, sites were taken forward for further consideration.

3.1.1.3 The criteria used in screening for European Sites takes account of the location of the sites relative to Hornsea Three, the ZoI of potential impacts associated with Hornsea Three and the ecology and distribution of qualifying features. These criteria are described in Table 3.1.

3.1.1.4 Further detail on the site selection criteria used in the screening exercise, broken down for Annex I habitats, Annex II species and bird qualifying features can be found in Annex 1: HRA Screening Report.

Table 3.1: Criteria used for initial identification of sites.

Criteria used for initial identification of European Site	
1	European Site overlaps with Hornsea Three boundary.
2	European Site supports mobile populations of qualifying features (e.g., Annex I birds, Annex II marine mammals, migratory fish, bats and otters) that may interact with potential effects associated with Hornsea Three).
3	European Site with qualifying features/species which foraging or migratory range overlaps with Hornsea Three.
4	European Sites and/or qualifying features located within the potential ZoI[6] of impacts associated with Hornsea Three (e.g., habitat loss/disturbance, increase in suspended sediment and sediment deposition, noise and risk of collision).
5	European Sites with primary reasons or qualifying features for site selection recorded during zonal-specific surveys.

3.2 Potential impacts

3.2.1.1 The potential impacts arising from the construction, operation and maintenance and decommissioning of Hornsea Three are summarised in Table 3.2 and Table 3.3. Further information on how impacts to benthic ecology (annex I habitats) interact with the conservation objective attributes can be found within Section 5 and Appendix A.

3.2.1.2 For the purposes of this report, and given the limited information currently available in respect to decommissioning, potential impacts during this phase have been assumed to be similar to (and not worse than) those predicted during the construction for all receptors.

[6] ZoI is defined for relevant features in Section 3.4

Table 3.2: Anticipated effects of offshore components of Hornsea Three on relevant features.

Project phase	Receptor type	Effect	Justification
Construction	Benthic habitats*	Temporary habitat loss/ disturbance	There is potential for temporary, direct habitat loss and disturbance due to cable laying operations (including anchor placements), spud-can leg impacts from jack-up operations and seabed preparation works for turbine foundations.
		Temporary increases in suspended sediments / smothering	Sediment disturbance arising from construction activities (e.g. cable and foundation installation) may result in adverse and indirect impacts on benthic communities as a result of temporary increases in suspended sediment concentrations and associated sediment deposition.
		Accidental pollution	There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.
	Diadromous fish species	Temporary habitat loss/disturbance	There is potential for temporary, direct habitat loss and disturbance due to cable laying operations (including anchor placements), spud-can leg impacts from jack-up operations and seabed preparation works for foundations.
		Temporary increases in suspended sediments/deposition	Sediment disturbance arising from construction activities (e.g. cable and foundation installation) may result in adverse and indirect impacts on fish. There is potential for sediment deposition/smothering of fish habitats as a result of sediment plumes generated during construction activities (e.g. cable and foundation installation).
		Underwater noise	Construction activities, in particular the pile-driving of foundations, will result in the highest levels of underwater noise, that may result in mortality, injury and behavioural effects on fish.
		Accidental pollution	There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may adversely affect fish and shellfish receptors.
	Marine Mammals	Underwater noise	There is the potential for underwater noise arising from foundation piling and other construction activities (e.g. drilling of piles) within the Hornsea Three array and offshore cable corridor (i.e. for the offshore HVAC booster station) area to cause physical/auditory injury or disturbance to marine mammals.
		Vessel noise	Increased vessel traffic during construction may result in an increase in noise disturbance to marine mammals.
		Collision risk	Increased vessel traffic during construction may result in an increased collision risk to marine mammals.
		Temporary increase in suspended sediments	There is the potential that increased suspended sediments, arising from construction activities such as cable and foundation installation, may impair the foraging ability of marine mammals.
		Accidental pollution	There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may lead to impacts on marine mammals.
		Prey availability	Changes in the fish and shellfish community resulting from construction impacts may lead to a loss in prey resources for marine mammals.
	Ornithology	Direct temporary habitat loss/disturbance	The impact of construction activities such as increased vessel activity and underwater noise may result in direct disturbance or displacement of birds from important feeding and roosting areas.
		Indirect temporary habitat loss/ disturbance	The impact of construction activities such as increased vessel activity and underwater noise may result in disturbance or displacement of prey from important bird feeding areas.
Operation and Maintenance	Benthic ecology*	Permanent habitat loss	There is the potential for permanent habitat loss to occur directly under all foundation structures and associated scour protection, and all subsea cables, where secondary cable protection is required.
		Colonisation of hard structures	Man-made structures placed on the seabed (foundations and scour/cable protection) are expected to be colonised by a range of marine organisms leading to localised increases in biodiversity. These structures also have the potential to act as artificial reefs serving as a refuge for fish and may facilitate the spread of non-native species.
		Changes in physical processes	The presence of foundation structures, associated scour protection and cable protection may introduce changes to the local hydrodynamic and wave regime, resulting in changes to the sediment transport pathways and associated effects on benthic ecology. Some benthic species and communities may be more vulnerable to reductions in water flow if the decrease is sufficient to reduce the availability of suspended food particles, and consequently inhibit feeding and growth. Scour and increases in flow rates can change the characteristics of the sediment potentially making the habitat less suitable for some species.
		Temporary seabed disturbance	Temporary disturbance/alteration of seabed habitats may occur during the operation and maintenance phase of Hornsea Three as a result of maintenance operations. The impacts associated with these operations are likely to be similar in nature to those associated with the construction phase although of reduced magnitude.

Project phase	Receptor type	Effect	Justification
		Accidental pollution	There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.
	Diadromous fish species	Long-term habitat loss	There is the potential for long-term loss of fish and shellfish habitat to occur directly under all foundation structures and associated scour protection, and all subsea cables, where secondary cable protection is required.
		Underwater noise	Underwater noise as a result of operational turbines and maintenance vessel traffic has the potential to result in effects on fish and shellfish receptors.
		Colonisation of hard structures	The introduction of man-made structures on the seabed (foundations and scour/cable protection) may lead to effects on fish and shellfish receptors by creating reef habitat.
		EMF	EMF emitted by array and export cables during the operational phase has the potential to result in behavioural responses on fish.
		Temporary seabed disturbance	Temporary disturbance/alteration of seabed habitats may occur during the operation and maintenance phase of Hornsea Three as a result of maintenance operations (i.e. jack-up operations).
		Accidental pollution	There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves.
	Marine mammals	Operational noise	The operating noise of turbines may result in potential effects on marine mammals.
		Vessel noise	Increased vessel traffic during operation and maintenance may result in an increase in noise disturbance to marine mammals.
		Collision risk	Increased vessel traffic during operation and maintenance may result in an increased collision risk to marine mammals.
		EMFs	EMF emitted by array and export cables may potentially affect marine mammal behaviour.
		Accidental pollution	There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves. The release of such contaminants may lead to impacts on the marine mammals.
		Prey availability	Changes in the fish and shellfish community resulting from operation and maintenance impacts may lead to a loss in prey resources for marine mammals.
	Ornithology	Permanent habitat loss/disturbance	The impact of physical displacement from an area around turbines and other ancillary structures during the operational phase of the development may result in effective habitat loss and reduction in species survival rates and fitness. No permanent habitat loss within the intertidal zone is predicted.
		Collision	Collisions with rotating turbine blades will result in direct mortality of an individual. Increased mortality may reduce species' survival rates.
		Barrier effect	The impact of barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration. Additional energetic costs incurred may reduce fitness and survival rate of a species.
		Temporary habitat loss/disturbance	The impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of birds. Within the intertidal zone, this applies only to little tern, which has been observed to forage within near shore areas. There are no other intertidal VORs that are predicted to be affected by construction activities.
Decommissioning	Effects are assumed to be similar to those predicted during the construction phase for all receptors		

*Effects on benthic ecology in relation to the specific attributes of the Conservation Objectives have been considered further in Appendix A.

Table 3.3: Predicted effects of onshore components of Hornsea Three on relevant features.

Project phase	Receptor type	Effect
Construction	Habitats	Temporary habitat loss from the construction of the onshore substation and HVAC booster station.
		Temporary disturbance/damage to habitats from the installation of the onshore infrastructure.
		Potential accidental release of contaminants.
	Species	Temporary loss of habitat from the construction of the onshore substation and onshore HVAC booster station.
		Temporary disturbance/damage to species from the installation of the onshore infrastructure.
		Habitat fragmentation or severance associated with cable trenching (otters and bats).
		Potential accidental release of contaminants.
Operation	Habitats	Temporary disturbance/damage to habitats from operation and maintenance activities.
		Potential accidental release of contaminants.
	Species	Temporary disturbance/damage to species from operation and maintenance activities.
		Potential accidental release of contaminants.
Decommissioning	Effects are assumed to be similar to those predicted during the construction phase for all receptors	

3.3 Sites considered during HRA Screening

3.3.1.1 The sites considered for LSE are listed in full in Annex 1: HRA Screening Report.

3.3.2 Sites designated for benthic Annex I habitats

3.3.2.1 For the purpose of this report benthic Annex I habitats are qualifying Annex I features that occur seaward of MHWS.

3.3.2.2 It was assumed there is a LSE on any site which includes Annex I benthic habitats that is directly affected by Hornsea Three. In this instance, 'Direct' means where the Hornsea Three array area or the offshore cable corridor search area is within or passes through the European Site boundary.

3.3.2.3 In addition to direct effects, for sites designated for benthic Annex I habitats, there may be potential for indirect effects, due to, for example:

- Changes in the hydrodynamic regime (waves and currents) as result of turbine structures leading to changes in baseline environment and as such on offshore and coastal habitats and non-mobile species; and
- Sediment mobilisation from turbine or cable installation which may be deposited on offshore and coastal habitats and non-mobile species.

3.3.2.4 The ZoI for the assessment of indirect effects has been determined through a review of the modelled zone of effects associated with increased suspended sediment concentrations during seabed preparation works for the construction of Project Two. The Project Two modelling was reviewed because of the proximity of Hornsea Three array to the Project Two array and the similarity with respect to the project design characteristics. On this basis, a 16 km buffer around the Hornsea Three array area has been included which takes into account the predicted suspended sediment dispersal of up to 2 mg/l. A buffer of one tidal excursion[7] (approximately 12 km) from the Hornsea Three offshore cable corridor search area has also been included to capture the ZoI for cable installation works. This ensures that all sites potentially affected by changes in water quality (e.g. increased suspended sediment concentrations) and potential changes to the hydrodynamic regime were included in the assessment.

3.3.2.5 European Sites and associated designated features for which a LSE has been identified or could not be discounted are show in Table 3.4.

Table 3.4: European Sites designated for benthic Annex I habitat features for which a LSE has been identified or could not be discounted during HRA screening.

European Site	Annex I feature	Distance to array area (km)	Distance to offshore cable corridor search area (km)
North Norfolk Sandbanks and Saturn Reef SAC	• Sandbanks which are slightly covered by seawater all the time • Reefs	9	0
Haisborough, Hammond and Winterton SAC	• Sandbanks which are slightly covered by seawater all the time • Reefs	90	3
The Wash and North Norfolk Coast SAC	• Sandbanks which are slightly covered by sea water all the time • Mudflats and sandlflats not covered by seawater at low tide • Large shallow inlets and bays • Reefs • Salicornia and other annuals colonizing mud and sand • Atlantic salt meadow • Mediterranean and thermos-Atlantic halophilous scrubs • Coastal lagoons	120	0
Klaverbank SCI	• Reefs	11	18

3.3.3 Sites designated for Annex II diadromous migratory fish

3.3.3.1 It was assumed there is a LSE on any site which includes Annex II diadromous fish species as a feature that is directly affected by Hornsea Three. In this instance, 'Direct' means where the Hornsea Three array area or the offshore cable corridor search area is within or passes through the European Site boundary.

3.3.3.2 Annex II diadromous fish species which are features of SACs in the UK are as follows:

- Twaite shad *Alosa fallax*;
- Allis shad *Alosa alosa*;
- Atlantic salmon *Salmo salar*;
- Sea lamprey *Petromyzon marinus*; and
- River lamprey *Lampetra fluviatilis*.

[7] Distance of one (mean) spring tidal excursion derived from the underlying tidal current data used in the Atlas of Marine Renewable Energy.

3.3.3.3 It should be noted, however, that there are no sites designated for Annex II fish species which overlap with the Hornsea Three array area, nor with the offshore cable corridor search area and therefore no potential for impacts by direct means on these features are expected to occur as a result of Hornsea Three.

3.3.3.4 European Sites designated for diadromous fish features comprise of estuaries through which fish migrate and the freshwater reaches of rivers. Given that these species are mobile and make use of both the freshwater and marine/offshore environments throughout their life cycle, there could be potential, however, for Hornsea Three to result in impacts on Annex II diadromous species at some distance from the sites they are features of.

3.3.3.5 Taking a precautionary approach it has been considered that European Sites with Annex II diadromous fish features which are located within 100 km from either the array area or the offshore cable corridor search area could potentially be affected by Hornsea Three.

3.3.3.6 Following the screening criteria above, the European Sites designated for Annex II diadromous fish species listed in Table 3.5 were identified for assessment of LSE.

Table 3.5: European sites designated Annex II diadromous fish features for which a LSE was assessed during HRA screening.

European Site	Annex II feature	Distance to array area (km)	Distance to offshore cable corridor search area (km)
Humber Estuary SAC	• River lamprey • Sea lamprey	141	67
Humber Estuary Ramsar site	• Ramsar criterion 8 • River lamprey • Sea lamprey	141	67

3.3.3.7 As discussed within the HRA screening report the information available to date in relation to the distribution and use that these species make of the marine environment is limited. Both species are however most commonly found in coastal and/or estuarine areas whether in transit from and into home rivers and/or engaged in foraging activity.

3.3.3.8 Taking account of their habitat usage, distance from the Humber SAC (and Ramsar site) to the offshore cable corridor search area (67 km) and to the array area (141 km) it is therefore considered that there is limited potential for Hornsea Three to result in a detrimental impact on these features of this site. As such LSEs on river lamprey and sea lamprey as qualifying features of the Humber Estuary SAC (and Ramsar) are not predicted and no further assessment for Annex II diadromous fish species is required.

3.3.4 Sites designated for Annex II marine mammals

3.3.4.1 It was assumed there is a LSE on any site which includes Annex II marine mammals as a feature that is directly affected by Hornsea Three. In this instance, ‘Direct’ means where the Hornsea Three array area or the offshore cable corridor search area is within or passes through the European Site boundary.

3.3.4.2 Given that marine mammals are mobile species which potentially forage over wide areas, they could potentially be affected by activities that occur at some distance from the sites they are features of.

3.3.4.3 Taking a precautionary approach, and in order to ensure that that all sites potentially affected by noise effects (behavioural impacts) and potential changes to water quality are included (e.g. increased suspended sediment concentrations), all sites with Annex II marine mammal qualifying features located within the regional marine mammal study area (as defined in the Hornsea Three Scoping Report (DONG Energy, 2016a) were identified for assessment.

3.3.4.4 The regional study area is represented largely by SCANS Block U (Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report) as the central focus, extending further east and south. These sites together with their qualifying marine mammal Annex II species are listed in Table 3.6 below.

Table 3.6: European Sites designated for Annex II marine mammal features for which a LSE has been identified or could not be discounted during HRA screening.

Site	Features	Distance to array area (km)	Distance to offshore cable corridor search area (km)
Southern North Sea cSAC	Harbour porpoise	2	0
The Wash and North Norfolk Coast SAC	Harbour seal	120	0
Humber Estuary SAC (and Ramsar)	Grey seal	141	67
Doggersbank SCI (Dutch Doggerbank)	Harbour seal Grey seal	42	58
Klaverbank SCI	Harbour porpoise Grey seal Harbour seal	11	18
Noordzeekustzone SAC	Grey	138	138

3.3.5 Sites designated for ornithological features

3.3.5.1 It is assumed there is a LSE on any site which includes bird features as a feature that is directly affected by Hornsea Three. In this instance, ‘Direct’ means where the Hornsea Three array area or offshore cable corridor search area is within or passes through the European Site boundary.

3.3.5.2 The offshore cable corridor runs directly through the Greater Wash pSPA as a result a LSE on some of the features of this pSPA cannot be discounted, including wintering red-throated diver and common scoter.

3.3.5.3 In addition to impacts resulting from direct effects (i.e. based on overlap between Hornsea Three and European Sites), there may be potential for impacts on ornithological features of sites located further afield, where these forage and/or migrate through the Hornsea Three array area and/or offshore cable corridor search area. These features include:

- Breeding birds;
- Migratory seabirds; and
- Waterbirds (waders and wildfowl).

3.3.5.4 Key amongst these is Flamborough Head and Bempton Cliffs SPA/FFC pSPA and the breeding interest features gannet, kittiwake, herring gull, puffin, guillemot and razorbill. Hornsea Three is within foraging range of some of these breeding seabird features.

3.3.5.5 European Sites designated for birds, and their features, for which a LSE could not be discounted during HRA screening are listed in Table 3.7.

Table 3.7: European Sites designated for ornithological features for which LSE has been identified or could not be discounted during HRA screening.

European site	Features
Coquet Island SPA	• Fulmar
Greater Wash pSPA	• Red-throated diver • Common scoter • Sandwich tern
Farne Islands SPA	• Fulmar
FFC pSPA Flamborough Head and Bempton Cliffs SPA[8]	• Gannet (breeding, pre-breeding and post-breeding season) • Kittiwake (breeding, pre-breeding and post-breeding seasons) • Herring gull (non-breeding season) • Puffin (breeding and non-breeding season (all birds)) • Guillemot (breeding season (immature birds) and non-breeding season (all birds)) • Razorbill (breeding season (immature birds) and non-breeding seasons (all birds))
Forth Islands SPA	• Fulmar
North Norfolk Coast SPA	All features except tern species and Mediterranean gull
North Norfolk Coast Ramsar Site	All ornithological features of the Ramsar site excluding tern species

[8] Only kittiwake is a named qualifying feature of Flamborough Head and Bempton Cliffs SPA; gannet, herring gull, razorbill, guillemot and puffin are listed as contributing to an assemblage qualification.

3.3.6 Sites designated for Annex I habitats - onshore

3.3.6.1 Any site which includes Annex I habitats that is directly affected by Hornsea Three was screened into assessment along with all its interest features. In this instance, 'Direct' means where the onshore cable corridor search area, passes through the European Site boundary. Despite not direct affect by the onshore cable corridor, the North Norfolk Coast SAC and Ramsar sites have been included due to their close proximity.

3.3.6.2 European Sites designated for Annex I habitats identified following the criteria above, are listed in Table 3.8.

Table 3.8: European Sites designated for Annex I habitats (onshore) for which LSE has been identified or could not be discounted during HRA screening.

European Site	Features
Norfolk Valley Fens SAC (Sections of the site which overlap with the onshore cable corridor search area correspond with the Holt Lowes and Booton Common SSSIs)	• Alkaline fens (Calcium-rich springwater-fed fens) • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*). (Alder woodland on floodplains)* • Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. (Calcium-rich fen dominated by great fen sedge (saw sedge))* • European dry heaths • Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*). (Purple moor-grass meadows) • Northern Atlantic wet heaths with *Erica tetralix* (Wet heathland with cross-leaved heath) • Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) (Dry grasslands and scrublands on chalk or limestone)
River Wensum SAC	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; Rivers with floating vegetation often dominated by water-crowfoot

European Site	Features
North Norfolk Coast SAC	• Coastal lagoons* • Fixed dunes with herbaceous vegetation (grey dunes). (Dune grassland)* • Embryonic shifting dunes • Humid dune slacks • Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*). (Mediterranean saltmarsh scrub) • Perennial vegetation of stony banks. (Coastal shingle vegetation outside the reach of waves) • Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes). (Shifting dunes with marram).
North Norfolk Coast Ramsar Site	Ramsar criterion 1: The site is one of the largest expanses of undeveloped coastal habitat of its type in Europe. It is a particularly good example of a marshland coast with intertidal sand and mud, saltmarshes, shingle banks and sand dunes. There are a series of brackish-water lagoons and extensive areas of freshwater grazing marsh and reed beds.

Annex I priority habitats are denoted by an asterisk (*)

3.3.7 Sites designated for Annex II species (excluding marine mammals and diadromous fish)

3.3.7.1 Any site which includes Annex II species that is directly affected by Hornsea Three was screened into assessment along with all its Annex II species features. In this instance, 'Direct' means where the onshore cable corridor search area, passes through the European Site boundary.

3.3.7.2 In addition, following CIEEM (2016) guidance, DMRB (2001) advice note and Collins (2016) guidance, specific qualifying features were included in the assessment, taking account of their distribution and ecology, as follows:

- Otters: Sites within a 5 km buffer around the onshore cable corridor search area, were also included for assessment; and
- Bats: Sites within a 10 km buffer around the onshore cable corridor search area were considered for inclusion into the assessment. Note however that given that the closest European Site with bats as qualifying features (Paston Great Barn SAC) is located 18 km from the onshore cable corridor area, and is therefore outside of the potential ZoI in respect to these species. As such, sites designated for bats as qualifying features were scoped out for further consideration and assessment.

3.3.7.3 European Sites designated for Annex II species taken forward for determination of LSE, following the criteria set out above, are listed in Table 3.9.

Table 3.9: European Sites designated for Annex II species (onshore) for which LSE has been identified or could not be discounted during HRA screening.

European Site	Feature	Distance from onshore cable corridor search area (km)
Norfolk Valley Fens SAC	• Narrow-mouthed whorl snail *Vertigo angustior* • Desmoulin's whorl snail *Vertigo moulinsiana*	0
River Wensum SAC	• Desmoulin`s whorl snail *Vertigo moulinsiana* • White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes* • Brook lamprey *Lampetra planeri* • Bullhead *Cottus gobio*	0
The Wash and North Norfolk Coast SAC	• Otter *Lutra lutra*	0
North Norfolk Coast SAC	• Otter *Lutra lutra* • Petalwort *Petalophyllum ralfsii*	0
The Broads SAC	• Desmoulin's whorl-snail *Vertigo moulinsiana* • Little whirlpool ram's-horn snail *Anisus vorticulus* • Fen orchid *Liparis loeselii* • Otter *Lutra lutra*	5
Broadland Ramsar site	**Ramsar criterion 2:** The site supports a number of rare species within the biogregraphical zone context, including the following Annex II species: • Desmoulin`s whorl snail *Vertigo moulinsiana* • Otter *Lutra lutra* • Fen orchid *Liparis loeselii*	5

3.4 Likely Significant Effects

3.4.1.1 Following consultation on the HRA Screening Report, including meetings of Expert Working Groups (EWG) through the Evidence Plan process, there has been refinement of the features for which an LSE is predicted. Detailed information on the rationale for determination of LSE is provided in Annex 1: HRA Screening Report. This presents the sites, features and potential impacts for which LSEs could not be excluded at the screening stage.

3.4.1.2 Amendments to the initial screening conclusions for each receptor group are described below and an updated summary of sites, features and potential impacts to be brought forward for AA, and hence discussed within this RIAA are detailed in Table 3.10 and Table 3.11 and shown in Figure 3.1 and Figure 3.2 for offshore sites and onshore sites respectively.

3.4.2 Benthic ecology

3.4.2.1 Annex I habitats of the sites screened in for assessment occuring seaward of MHWS are considered within the Benthic Annex I Habitats assessment (see Section 5). Potential impacts on the Annex I habitats of European Sites from Hornsea Three landward of MHWS screened in for assessment are considered within the Onshore Ecology assessment (see Section 8).

3.4.2.2 Four European Sites present within close proximity to Hornsea Three were taken forward for assessment following Stage 1 screening in relation to benthic ecology. These were:

- The Wash and North Norfolk Coast SAC ;
- Haisborough, Hammond and Winterton SAC ;
- North Norfolk Sandbanks and Saturn Reef SAC ; and
- Klaverbank SCI.

3.4.2.3 Updates in the form of two offshore cable corridor reroutes have been made to the Hornsea Three offshore cable corridor described in the screening report and subsequent Draft RIAA as a result of the consultation process. These updates do not result in the requirement for inclusion or consideration of any additional European Sites other than those listed above, however; The Wash and North Norfolk Coast SAC had previously been screened out for Stage 2 AA. The cable corridor reroute in the near shore area now results in the requirement for a Stage 2 AA of the following qualifying benthic Annex I features of this site:

- Sandbanks which are slightly covered by seawater all the time
- Reefs

3.4.2.4 It is noted that the reroute does not alter the proposed landfall location and as such the intertidal Annex I qualifying features of the Wash and North Norfolk SAC remain screened out due to no impact pathway being identified.

3.4.2.5 In summary the North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC overlap with the updated Hornsea Three cable corridor. The other sites listed above do not overlap with the offshore cable corridor but may fall within the wider area of effect (e.g. from increased suspended sediment) due to their proximity to the offshore cable corridor (Environmental Statement, volume 2, chapter 2: Benthic Ecology). Concentrations of suspended sediments are predicted to fall to near background levels within hundreds of metres/several kilometres; furthermore, neither ‘Reefs’ (i.e. *Sabellaria* reefs) nor the ‘Sandbanks’ features (i.e. their supporting fauna) would be expected to be particularly sensitive to increases in SSC or sediment deposition.

3.4.2.6 The only transboundary impact that may result for Hornsea Three is increased SSC that may reach Klaverbank SCI. The Klaverbank SCI is 11 km from the Hornsea Three array area, within the Dutch jurisdiction. This site is designated for Annex I 'reefs', which is the primary reason for the designation of the site. However, as discussed in Environmental Statement volume 2, chapter 2: Benthic Ecology, elevations in SSC above background levels at distances of hundreds of metres to a few kilometres are predicted to be relatively low (i.e. less than ~20 mg/l) and within the range of natural variability and after 24 hours, elevations in SSC are predicted to typically be less than 5 mg/l. Therefore by the time that a plume might reach Klaverbank SCI, the SSC and any associated deposition are predicted to be at background levels, and are therefore expected to have negligible effects on the benthic receptors.

3.4.2.7 For the above reasons the only European Sites considered in the Environmental Statement are the North Norfolk Sandbanks and Saturn Reef SAC and the Wash and North Norfolk coast SAC. This approach is mirrored here in the RIAA which therefore also includes no transboundary assessment.

3.4.2.8 Discussions within the EWG led to the decision to include the assessment of non-native species as an impact to benthic ecology, within the assessment of colonisation of hard substrate within this RIAA, although this had not previously been included at the screening stage.

3.4.3 Marine mammals

3.4.3.1 Following consultation on the HRA Screening Report it was agreed with the marine mammal EWG (see Consultation Report, Annex 1 Evidence Plan) that the potential effects of accidental pollution, vessel noise and collision risk would be assessed for each interest feature that is screened in to the assessment.

3.4.3.2 Following consultation on the HRA Screening, it was requested that the grey seal feature of the Voordelta SAC be included in the HRA screening. As the Voordelta SAC is more than 145 km from the array area or the offshore ECR corridor search area, it is concluded that there is no potential for LSE on the grey seal feature of this site.

3.4.3.3 It was requested by Natural England, through the Scoping Response, that effects on prey availability should be considered for marine mammals and it was agreed through the Evidence Plan process (see Consultation Report, Annex 1 Evidence Plan) that this impact would be considered further pending outcomes of investigations into marine processes effects. No significant effect has been identified within the Marine Processes assessment, or in turn within the fish and shellfish ecology assessments (Environmental Statement volume 2, chapters 1 and 3) and as such potential effects on prey availability are not considered further in this RIAA.

3.4.4 Offshore ornithology

3.4.4.1 Following consultation it was requested within Natural England's Scoping response that effects on prey availability should be considered for ornithological features and it has been agreed through the Evidence Plan process, that this impact will be considered if the marine processes assessment identifies connectivity, with specifically the Flamborough Front. The Marine Processes assessment has concluded no significant impact on the Flamborough Front and therefore this effect has not been assessed.

3.4.4.2 Natural England requested in their responses to screening (Annex 1: HRA Screening Report) clarification of the reasons for screening out the following interest features:

- Breeding lesser black-backed gull interest feature of the Alde-Ore Estuary SPA;
- Breeding tern features of the North Norfolk Coast SPA / Greater Wash pSPA;
- Breeding razorbill and guillemot at the Flamborough and Filey Coast pSPA; and
- Breeding seabird features in the non-breeding season.

3.4.4.3 In addition to these features, further information has been requested during EWG meetings in relation to connectivity between the razorbill and guillemot features of the FFC pSPA and Hornsea Three. This detail is provided in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA. Natural England's Section 42 comments also requested further information in relation to screening for the tern features of the Greater Wash pSPA (Sandwich tern, common tern and little tern) and impacts on breeding seabirds in the non-breeding season. This is provided in Annex 2: Additional Special Protection Areas Screening Exercise. The results of this additional screening exercise are summarised below.

Lesser black-backed gull, Alde-Ore Estuary SPA

3.4.4.4 The Alde-Ore Estuary SPA, which is 90 km from Hornsea Three, is the only SPA (or pSPA) for which lesser black-backed gull is cited as a breeding feature and has potential connectivity with Hornsea Three based on the mean-maximum foraging range of the species (141 km; Thaxter *et al.* 2012). Connectivity is limited to the offshore cable corridor and not the Hornsea Three array area. Lesser black backed gull is amongst one of the most flexible species in their habitat use and may be observed taking advantage of new foraging opportunities created by human activity (e.g. construction activities that may increase prey availability). Consequently no pathway for an adverse effect has been identified for lesser black backed gull and, therefore, it is considered that there is no potential for a LSE on this species at the Alde-Ore Estuary SPA to occur as a consequence of Hornsea Three.

3.4.4.5 No further consideration is therefore given to lesser black-backed as a breeding seabird qualifying features of the Alde-Ore Estuary SPA or any other European site.

Tern features, North Norfolk Coast SPA and Greater Wash pSPA

3.4.4.6 Natural England in their responses to the screening exercise (Annex 1: HRA Screening Report) queried the reasons for screening out foraging tern species that are features of the North Norfolk Coast SPA, although the same species that are features of the Greater Wash pSPA were screened into the assessment. It was subsequently agreed in EWG meetings for offshore ornithology, that assessments made for the Greater Wash pSPA are equally applicable to the North Norfolk Coast SPA.

3.4.4.7 The HRA Screening Report concluded that there would be no LSE on the tern features of the Greater Wash pSPA as a result of activities associated with the construction and operational phases of the Hornsea Three export cable route. This was conclusion was reached because it is was assessed that tern features of the Greater Wash pSPA have a low sensitivity to the impacts associated with the installation of the export cable (Wade *et al.,* 2016). The information provided in Annex 2: Additional Special Protection Areas Screening Exercise concludes that Sandwich tern should be included in the RIAA due to potential overlap between the export cable route (which has been refined since the production of the HRA Screening Report) and the foraging areas of Sandwich tern that form part of the Greater Wash pSPA. No connectivity was identified between the foraging areas of common tern and little tern from breeding colonies that form part of the North Norfolk Coast pSPA and therefore the conclusions reached for these species (i.e. no potential for LSE) are considered valid.

One of the justifications for the proposal for the Greater Wash pSPA is to protect the foraging waters of terns associated with the North Norfolk Coast SPA. Consequently as no potential for LSE has been predicted for foraging common and little terns within the Greater Wash pSPA, there is no potential for LSE on these species within the North Norfolk Coast SPA.

Razorbill and guillemot, FFC pSPA

3.4.4.8 As part of EWG meetings, it has been suggested that further sources of information, namely tracking data obtained for razorbill and guillemot from a number of UK breeding colonies and Wakefield *et al*. (2017), be used to identify whether there is evidence to suggest connectivity between breeding birds at FFC pSPA and Hornsea Three. This information is considered in Annex 3: Phenology, connectivity and apportioning for breeding features of FFC pSPA and it is concluded that there is no connectivity between Hornsea Three and the breeding razorbill and guillemot features of FFC pSPA in the breeding season. These features of FFC pSPA are therefore considered in the non-breeding season only. Impacts on immature razorbill and guillemot associated with FFC pSPA are considered in all seasons.

Breeeding seabirds in the non-breeding season

3.4.4.9 Annex 2: Additional Special Protection Areas Screening Exercise considers potential impacts on breeding seabirds in the non-breeding season for all displacement and collision impacts on relevant Valued Ornithological Receptors (VORs) identified in Environmental Statement volume 5, annex 5.1: Baseline Characterisation. A conclusion of no potential for LSE is reached where an apportioned impact in each relevant non-breeding season for a species (post-, non- and/or pre-breeding seasons) does not surpass 1% of the relevant SPA population. Using this threshold a conclusion of no potential for LSE is reached for all species at all SPAs included in the screening exercise.

3.4.5 Onshore ecology

3.4.5.1 The potential for LSE associated with accidental pollution events on onshore Annex I Habitat features was screened out during stage 1 of the HRA process, however; after consultation with Natural England it has been agreed to bring this potential effect forward for AA. In addition to accidental pollution events, invasive non-native species are also now screened into the RIAA.

Table 3.10: European Sites and features for which LSEs have been identified/cannot be discounted (offshore).

Receptor	Site	Feature	Project phase	Effect
Benthic Ecology	North Norfolk Sandbanks and Saturn Reef SAC	Sandbanks which are slightly covered by seawater all the time Reefs	Construction / Decommissioning	Temporary habitat loss/disturbance Temporary increases in suspended sediments/smothering Accidental pollution events
			Operation and maintenance	Long-term habitat loss Colonisation of hard structures Changes in physical processes Temporary seabed disturbance Accidental pollution events
	The Wash and North Norfolk Coast SAC	Sandbanks which are slightly covered by seawater all the time Reefs	Construction / Decommissioning	Temporary habitat loss/disturbance Temporary increases in suspended sediments/smothering Accidental pollution events
			Operation and maintenance	Long-term habitat loss Colonisation of hard structures Changes in physical processes Temporary seabed disturbance Accidental pollution events
Marine Mammals	The Wash and North Norfolk Coast SAC	Harbour seal	Construction / Decommissioning	Underwater noise from foundation installation and UXO clearance Increased vessel traffic and collision risk Accidental pollution events
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events
	Doggersbank SCI (Dutch designation)	Harbour seal Grey seal	Construction / Decommissioning	Underwater noise from foundation installation and UXO clearance Increased vessel traffic and collision risk Accidental pollution events
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events
	Klaverbank SCI	Harbour seal Grey seal Harbour porpoise	Construction / Decommissioning	Underwater noise from foundation installation and UXO clearance Increased vessel traffic and collision risk Accidental pollution events
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events
	Humber Estuary SAC/Ramsar	Grey seal	Construction / Decommissioning	Underwater noise from foundation installation and UXO clearance Increased vessel traffic and collision risk Accidental pollution events
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events
	Noordzeekustzone SAC	Grey seal	Construction/Decommissioning	Underwater noise from foundation installation and UXO clearance Increased vessel traffic and collision risk Accidental pollution events

Receptor	Site	Feature	Project phase	Effect
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events
	Southern North Sea cSAC	Harbour porpoise	Construction/Decommissioning	Underwater noise from foundation installation and UXO clearance Increased vessel traffic and collision risk Accidental pollution events
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events
Offshore Ornithology	Greater Wash pSPA	Red-throated diver Common scoter	Construction/decommissioning	Disturbance
			Operation and maintenance	Displacement
		Sandwich tern	Construction/decommissioning	Disturbance Changes to prey availability
	FFC pSPA Flamborough Head and Bempton Cliffs SPA	Gannet (breeding, pre-breeding and post-breeding season)	Operation and maintenance	Collision risk Displacement
		Kittiwake (breeding, pre-breeding and post-breeding seasons)	Operation and maintenance	Collision risk
		Puffin (breeding season (immature birds) non-breeding season (all birds))	Construction/decommissioning	Disturbance
			Operation and maintenance	Displacement
		Guillemot (breeding season (immature birds) non-breeding season (all birds))	Construction/decommissioning	Disturbance
			Operation and maintenance	Displacement
		Razorbill (breeding season (immature birds) non-breeding seasons (all birds))	Construction/ decommissioning	Disturbance
			Operation and maintenance	Displacement
	Coquet Island SPA	Fulmar (breeding, post-breeding, non-breeding and pre-breeding seasons)	Operation	Displacement
	Farne Islands SPA	Fulmar (breeding, post-breeding, non-breeding and pre-breeding seasons)	Operation	Displacement
	Forth Islands SPA	Fulmar (breeding, post-breeding, non-breeding and pre-breeding seasons)	Operation	Displacement

Table 3.11: European Sites and features for which LSEs have been identified/cannot be discounted (onshore).

	Site	Feature		Project phase	Effect
Terrestrial Ecology	Norfolk Valley Fens SAC	Annex I habitats	All qualifying features	Construction/Decommissioning	Permanent habitat loss Temporary habitat disturbance/damage Accidental pollution events
				Operation and maintenance	Temporary habitat disturbance/damage Accidental pollution events
		Annex II species	All qualifying features	Construction/Decommissioning	Permanent habitat loss Temporary disturbance/damage Accidental pollution events
				Operation and maintenance	Temporary disturbance/damage Accidental pollution events
	River Wensum SAC	Annex I habitats	All qualifying features	Construction/Decommissioning	Permanent habitat loss Temporary habitat disturbance/damage Accidental pollution events
				Operation and maintenance	Temporary habitat disturbance/damage Accidental pollution events
		Annex II species	All qualifying features	Construction/Decommissioning	Permanent habitat loss Temporary disturbance/damage Accidental pollution events
				Operation and maintenance	Temporary disturbance/damage Accidental pollution events
	North Norfolk Coast SAC	Annex I habitats	All qualifying features	Construction/Decommissioning	Permanent habitat loss Temporary habitat disturbance/damage Accidental pollution events
				Operation and maintenance	Temporary habitat disturbance/damage Accidental pollution events
		Annex II species	All qualifying features	Construction/Decommissioning	Permanent habitat loss Temporary disturbance/damage Accidental pollution events
			Otter	Construction/Decommissioning	Habitat fragmentation
			All qualifying features	Operation and maintenance	Temporary disturbance/damage Accidental pollution events
	The Wash and North Norfolk Coast SAC	Annex II species	Otter	Construction/Decommissioning	Permanent habitat loss Temporary disturbance/damage to supporting habitat Accidental pollution events

	Site	Feature		Project phase	Effect
					Habitat fragmentation
				Operation and maintenance	Temporary disturbance/damage to supporting habitat Accidental pollution events
	North Norfolk Coast SPA	Ornithological features	All features excluding tern species and Mediterranean gull	Construction	Permanent habitat loss Temporary habitat disturbance/displacement Accidental pollution events
				Operation and maintenance	Temporary habitat disturbance/displacement Accidental pollution events
	North Norfolk Coast Ramsar Site	Annex I habitats	All qualifying features	Construction	Permanent habitat loss Temporary habitat disturbance/damage Accidental pollution events
				Operation and maintenance	Temporary habitat disturbance/damage Accidental pollution events
		Ornithological features	All features excluding tern species	Construction	Permanent habitat loss Temporary habitat disturbance/displacement Accidental pollution events
				Operation and maintenance	Temporary habitat disturbance/displacement Accidental pollution events

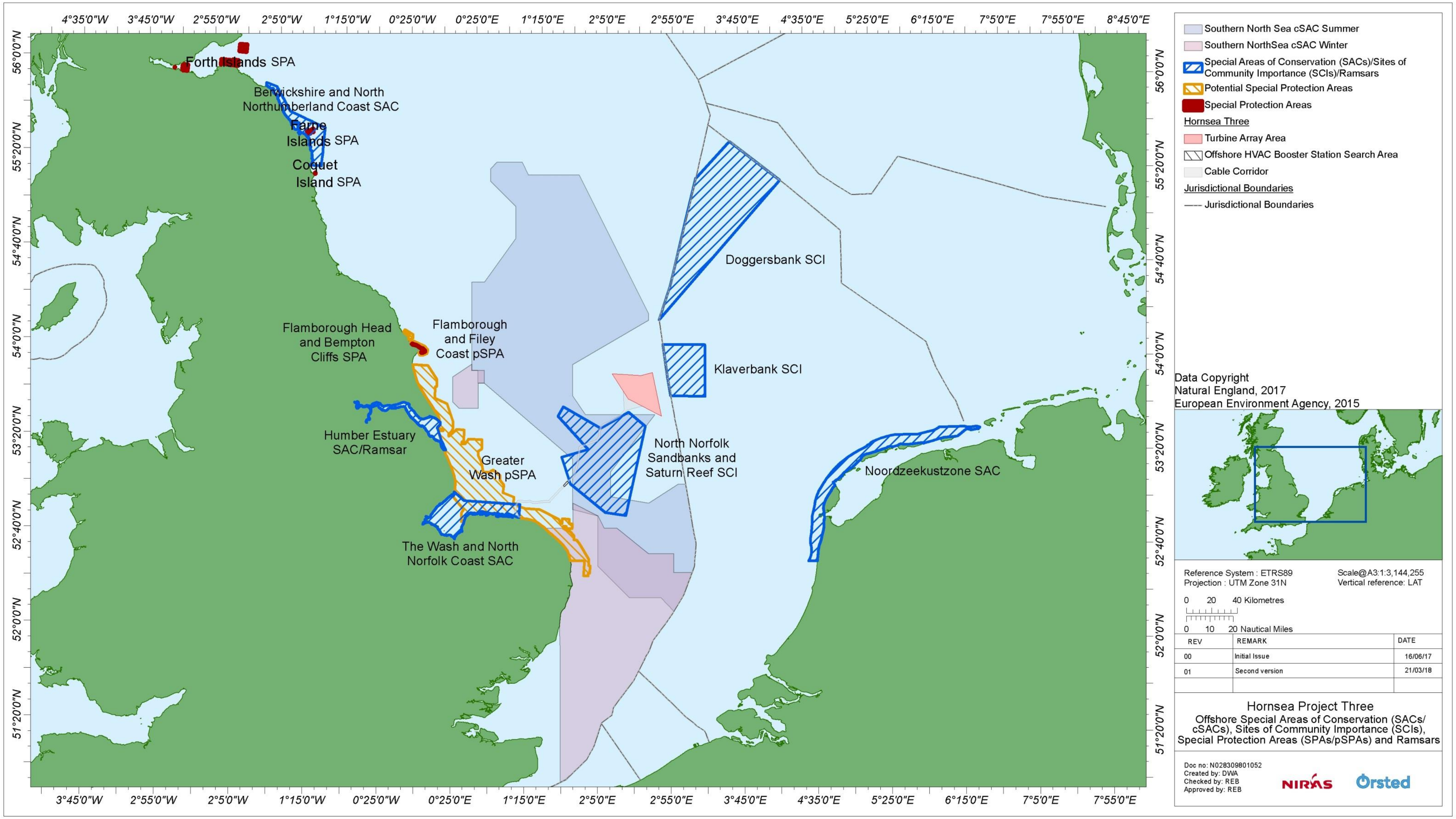


Figure 3.1: European Sites with qualifying features for which LSEs have been identified / cannot be discounted (offshore).

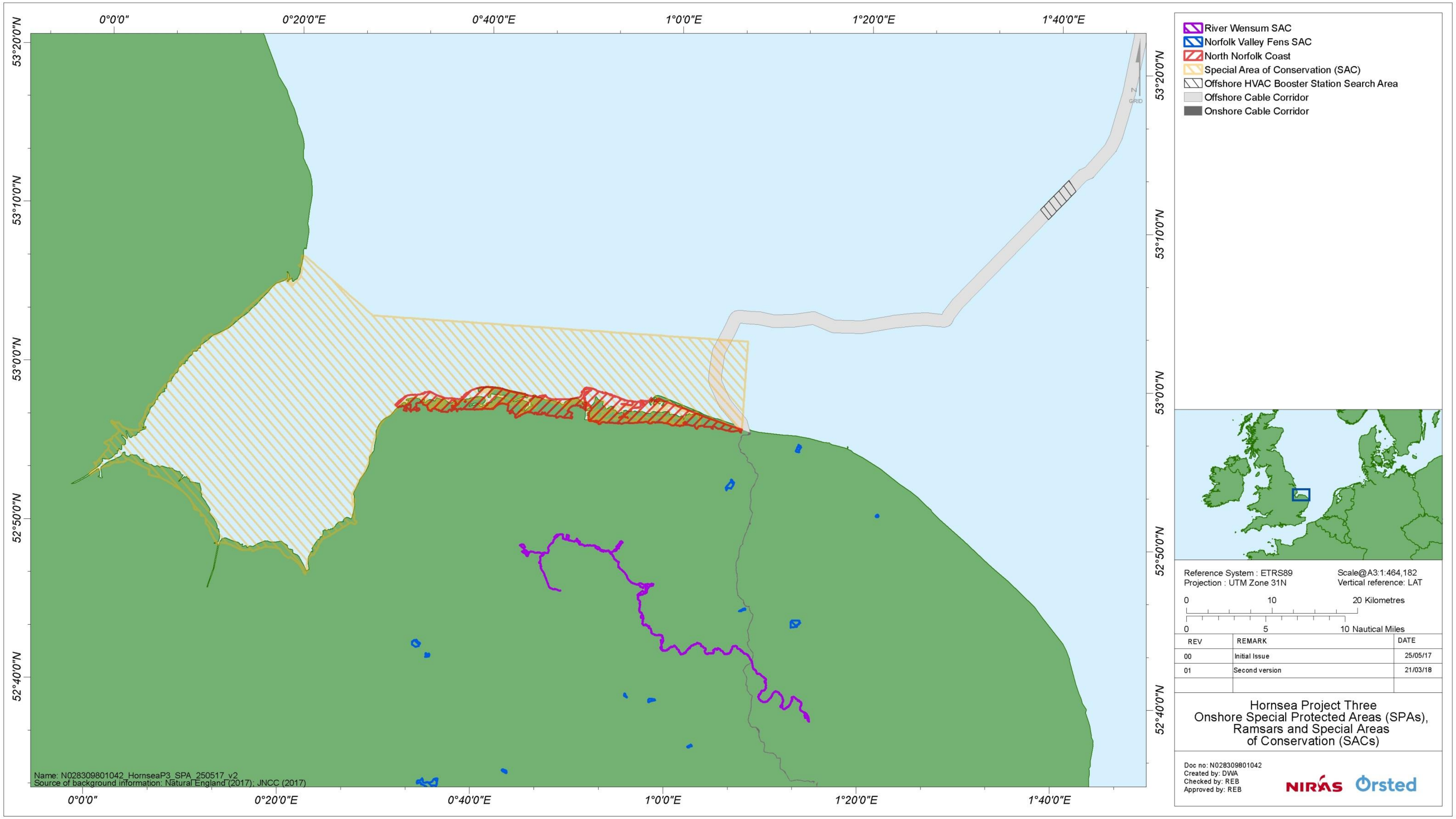


Figure 3.2: European Sites with qualifying features for which LSEs have been identified (onshore).

4. Information to Inform the Appropriate Assessment

4.1 Introduction

4.1.1.1 As described in Section 3 above, a European Site is progressed to the AA Stage (Stage 2 of the HRA) where it is not possible to exclude a LSE on one or more of its qualifying features in view of the Conservation Objectives. European Sites, features and potential impacts requiring an AA for Hornsea Three are therefore those for which LSEs could not be ruled out during the screening exercise.

4.1.1.2 Relevant information to help inform the AA is provided in the sections below, including a description of the European Sites under consideration and their interest features, as well as an assessment of potential effects on site integrity in light of the Conservation Objectives of each site. This is given separately for Annex I habitats, Annex II marine mammals, offshore ornithology and onshore ecology.

4.2 Maximum design scenarios

4.2.1.1 The maximum design scenarios identified in Table 4.1 to Table 4.4 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The assessment scenarios presented are consistent with those used for assessment in relevant Chapters of the Environmental Statement, as follows:

- Volume 2, Chapter 1: Marine Processes;
- Volume 2, Chapter 2: Benthic Subtidal and Intertidal Ecology;
- Volume 2, Chapter 3: Fish and Shellfish Ecology;
- Volume 2, Chapter 4: Marine Mammals;
- Volume 2, Chapter 5: Ornithology;
- Volume 2, Chapter 7: Shipping and Navigation; and
- Volume 3, Chapter 3: Ecology and Nature Conservation.

Table 4.1: Maximum design scenario considered for the assessment of potential impacts on benthic ecology - Annex I habitats

Potential impact	Maximum design scenario	Justification
Construction phase		

Temporary habitat loss/disturbance due to cable laying operations (including anchor placements and sandwave clearance), spud-can leg impacts from jack-up operations and seabed preparation works for gravity base foundations (GBFs), may affect benthic ecology.	***Hornsea Three offshore cable corridor***
	Total subtidal temporary habitat loss within the offshore cable corridor of up to 29,789,810 m² comprising:
	• Up to a total of 27,492,030 m² from burial of up to 978 km of export cable (up to six trenches of 163 km length) as follows:
	  • Up to a total of 18,396,180 m² due to 613.2 km of the export cable requiring sandwave clearance (up to 30 m wide corridor);
	  • Up to a total of 9,095,850 m² due to boulder clearance and cable laying (including remedial cable reburial during construction) of up to 363.8 km of export cable by trenching, mechanical cutting, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor for boulder clearance and 15 m wide corridor for cable installation).
	• Up to a total of 2,405,912 m² from placement of coarse, dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance on the offshore cable corridor, assuming a volume of up to 1,202,946 m³, placed on the seabed within the Hornsea Three offshore cable corridor.
	• Up to 339,600 m² from cable barge anchor placement associated with cable laying for subtidal export cables within the Hornsea Three offshore cable corridor broken down as follows:
	  • First 20 km of the offshore cable corridor: Up to seven anchors (footprint of 100 m² each) repositioned every 500 m for up to six export cables (20,000 m x seven x 100 m² x six / 500 m = 168,000 m²); and
	  • Export cables beyond 20 km: one anchor (footprint of 100 m²) repositioned every 500 m for up to six export cables ((163,000 m – 20,000 m) x one x 100 m² x six / 500 m = 171,600 m²).
	Hornsea Three intertidal area
	• Up to 12,642 m² from works to bury up to 500 m of cable length (from MHWS to MLWS) with up to six cable circuits (i.e. up to 3 km of export cable in the intertidal) by trenching (assuming habitat loss/disturbance within the entire corridor width) including associated construction activities.
		The maximum design scenario for temporary habitat loss has considered the burial of all subtidal cables, except where the necessary burial depth (i.e. to ensure adequate protection of the cable) cannot be achieved. Where sufficient burial is not possible, cable protection may be required (see permanent loss of seabed habitat impact below).
		The maximum design scenario for anchor placements (for cables >20 km offshore) has considered the placement of one anchor per 500 m of all cables. If more anchors are required, this would still fall within the maximum design scenario assessed as they would not be required for the entire cable length.
		The maximum design scenario for temporary habitat loss in the nearshore area from the installation of cables in the Hornsea Three intertidal area has considered the installation of all cables via open cut trenching, as the total potential temporary subtidal habitat loss associated with this method is greater than the temporary subtidal habitat loss associated with either the long HDD option (exit pit located approximately 800 m from MHWS mark) or the short HDD option (exit pit located approximately 200 m from MHWS mark), both of which would require the excavation of up to eight horizontal directional drilling (HDD) exits pits below MLWS (each up to 30 m in length and up to 30 m in width) and associated material disposal and jack-up activities in the vicinity of the exit pits (i.e. up to five jack-ups per exit pit equating to a total of 181 m²).
		The purposeful grounding of the cable installation barge (up to eight times) may also be required in the nearshore area affecting up to 600 m² per grounding event. The temporary habitat disturbance arising from this activity is, however, included within the 27,492,030 m² associated with burial of the export cable.
		Temporary habitat loss within the entire offshore cable corridor at the Hornsea Three intertidal area has been considered as the maximum design scenario (including anchor placements), though direct impacts (i.e. excavation) will only occur within a proportion of these areas.

Potential impact	Maximum design scenario	Justification

Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect benthic ecology.	***Cable installation***
	• Array cables
	  • Installation method: mass flow excavator;
	  • Total length 830 km;
	  • 4,980,000 m^3 total spoil volume from installation of up to 830 km cables in a V-shape trench of width = 6 m and depth =2 m (830 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 4,980,000 m^3); and
	  • 71,150 m^3 total spoil volume from sand wave clearance by dredging or mass flow excavation within the Hornsea Three array area (based on the Hornsea Three array area geophysical survey data combined with cable installation design specifications).
	• Interconnector cables
	  • Installation method: mass flow excavator;
	  • 15 interconnector cables, total length 225 km; and
	  • 1,350,000 m^3 total spoil volume from installation of up to 225 km cables in a V-shape trench of width = 6 m and depth =2 m (225 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 1,350,000 m^3).
	• Export cables
	  • Up to six cable trenches; each 191 km in length (1,146 km in total);
	  • Installation method: mass flow excavator;
	  • 6,876,000 m^3 total spoil volume from installation of up to 1,146 km cables in a V-shape trench of width = 6 m and depth =2 m (6 x 191 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 6,876,000 m^3); and
	  • 979,090 m^3 total spoil volume from sandwave clearance via either a dredger or mass flow excavator within the Hornsea Three offshore cable corridor (based on the Hornsea Three offshore cable corridor geophysical survey data combined with cable installation design specifications).
	Hornsea Three array area construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Pre-construction activities will occur one to two years prior to the start of the eight year construction. Cable installation up to 2.5 years within this time.
	Hornsea Three offshore cable corridor construction duration: up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Pre-construction activities will occur one to two years prior to the start of the eight year construction. Cable installation up to three years within this time.
		Cable installation may involve ploughing, trenching, jetting, rock-cutting, surface laying with post lay burial, and/or surface laying installation techniques. Of these, mass flow excavation will most energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum design scenario for sediment dispersion.
		The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length and shape) and the level to which the sandwave must be reduced (also accounting for stable sediment slope angles and the capabilities and requirements of the cable burial tool being used). Based on the available geophysical data, the bedforms requiring clearance are likely to be in the range 1 to 2 height in the array or 1 to 6 m in height in the offshore cable corridor.
		Sandwave clearance may involve dredging or mass flow excavation tools. Of these, mass flow excavation will most energetically disturb sediment in the clearance profile and as such is considered to be the maximum design scenario for sediment dispersion causing elevated SSC over more than a very short period of time. Dredging will result in a potentially greater instantaneous local effect in terms of SSC and potentially a greater local thickness of sediment deposition, but likely of a shorter duration and smaller extent, respectively. Note: this assessment considers effects on benthic ecology from a passive plume (i.e. sediments transported via tidal currents) during dredging and disposal operations. Placements of coarse dredged materials during dredge disposal are considered in temporary habitat loss.

Potential impact	Maximum design scenario	Justification

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	• Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation and up to 10,774 return trips during the construction phase:
	  • Up to four installation vessels (300 return trips), up to 24 support vessels (1,800 return trips) and up to 12 transport vessels (900 return trips) for wind turbine installation;
	  • Up to three installation vessels (300 return trips), up to 13 support vessels (1,500 return trips), up to 12 dredging vessels (1,200 return trips) and up to four transport vessels (tugs) (1,200 return trips) for wind turbine GBF installation;
	  • Up to two installation vessels (38 return trips), up to 12 support vessels (228 return trips) and up to four transport vessels (38 return trips) for offshore substation foundations installation;
	  • Up to three main cable laying vessels (315 return trips), up to three main cable burial vessels (315 return trips), support vessels comprising up to four crew boats or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, and up to two dredging vessels (1,890 return trips for support vessels) for array cable installation; and
	  • Up to four main laying vessels comprising up to one barge and three associated tugs (180 return trips), up to four main jointing vessels comprising up to one barge and three associated tugs (120 return trips), up to four main burial vessels comprising up to one barge and three associated tugs (180 return trips) and support vessels comprising up to two crew boats or SOVs, up to one service vessel, up to one diver vessel, up to one PLGR vessel, and up to one dredging vessel (270 return trips for support vessels) for export cable installation.
	• Water-based drilling muds associated with drilling to install foundations, should this be required;
	• A typical wind turbine is likely to contain up to 25,000 litres (l) of lubricants (hydraulic oil, gear oil and grease), up to 80,000 l of nitrogen, up to 7,000 l of transformer silicon/ester oil, up to 13,000 l of coolants, up to 2,000 l of diesel fuel and up to 6 kg of SF6;
	• A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates;
	• Offshore fuel storage tanks:
	  • One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and
	  • One on each of the up to three offshore accommodation platforms for crew transfer vessel (CTV) fuel and each with a capacity of 210,000 l.
	• Potential contamination of nearshore/intertidal habitats from drilling mud (bentonite) used to facilitate the installation of export cables in the intertidal via HDD.
		These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction and the offshore storage of fuel.

Operation phase		
Long term loss of seabed habitat through presence of foundations, scour protection and cable protection, resulting in potential effects on benthic receptors.	***Hornsea Three offshore cable corridor - cable protection*** • Up to a total of 684,600 m² based on the installation of cable protection for 10% of the up to 978 km of export cable. Assumes up to six cables, and up to 7 m width of cable protection per cable; • Up to a total of 660,000 m² for cable/pipeline crossings, with up to 44 crossings, assuming up to six cables, with each crossing having a long term loss of seabed (i.e. through placement of rock berms) of up to 2,500 m²; • Cable protection may comprise gravel, concrete mattresses, rock placement, bags filled with gravel, grout or other concrete, artificial fronds or seaweed or bags of grout, concrete, or another substance that cures hard over time; and • Replenishment of 25% of cable length and cable/pipeline crossings during the operation and maintenance phase. The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.	The maximum design scenario for long term habitat loss has considered the use of cable protection (i.e. rock placement) along 10% of the subtidal array cables and interconnector power cables. The maximum design scenario assumes that up to 10% of the subtidal export cables within designated sites will require cable protection (i.e. rock placement). The replenishment of cable protection and cable/pipeline crossings during the operation and maintenance phase will not result in any additional long term habitat loss as it is assumed that replenishment works will be additive in areas in which cable protection was laid during construction.
Colonisation of foundations/cable protection/scour protection may affect benthic ecology and biodiversity.	***Hornsea Three offshore cable corridor - cable protection*** • Up to a total of 846,640 m² from the installation of cable protection for 10% of the up to 978 km of export cables. Assumes an up to 7 m wide cable corridor, cable protection to an indicative height of up to 2 m and a berm 3 m wide at the top, giving a per metre surface area of approximately 8.7 m²; and • Up to a total of 660,000 m² from installation of cable protection for up to 44 cable/pipeline crossings (2,500 m² per crossing) along the offshore cable corridor. The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.	Maximum surface area created by turbines, substation and offshore accommodation platform foundations, scour protection and surface protection for cables where secondary cable protection is required. This assumes that 10% of inter-array and subtidal export cables require secondary protection.

Potential impact	Maximum design scenario	Justification
Increased risk of introduction or spread of invasive and non-native species (INNS) due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity.	Introduced hard substrate: • Maximum design scenario as above for "colonisation of foundations/cable protection/scour protection" impact above; and • Increased risk of introduction or spread of INNS from up to 10,774 vessel round trips during the construction phase (see "accidental release of pollutants" impact assessment above for breakdown) and up to 2,885 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels).	Maximum surface area created by offshore infrastructure as above for Colonisation of foundations/cable protection/scour protection impact. Maximum design scenario with regards to maximum number of vessel movements during operation and maintenance activities.
Alteration of seabed habitats arising from effects on physical processes, including scour effects and changes in the sediment transport and wave regimes resulting in potential effects on benthic ecology.	***Changes in wave and tidal regime*** • Largest number of GBFs for turbines (up to 300 of 43 m diameter) and offshore accommodation platforms (up to three of 41 m diameter) and the largest dimensions of GBF for offshore transformer substations (up to 12 of 75 m length scale) and offshore HVDC converter substations (up to four 75 m length scale) in the Hornsea Three array area; • Largest number of offshore HVAC booster station GBFs (up to four foundations, associated base dimensions 75 m) in the Hornsea Three offshore cable corridor; and • Minimum spacing of 1,000 m. ***Scour effects*** • Local scour around an individual turbine is greatest for a 15 m diameter monopile foundation; • Global scour around an individual turbine foundation is greatest for a piled jacket foundation of 40 m base length; • For the Hornsea Three array area as a whole, local scour footprint was greatest around an array of 160 x 15 m diameter monopile foundations; and • For the Hornsea Three array area as a whole, the global scour footprint was greatest for an array of 300 x piled jacket foundations of 33 m base diameter.	***Changes in wave and tidal regime*** The greatest total in-water column blockage to waves and currents is presented by the greatest number of GBFs in the array area, with at least the minimum spacing between turbines. This combination was determined via calculations that quantitatively compare the blockage presented by a range of minimum and maximum sizes of varying foundation types and numbers (see Environmental Statement volume 5, annex 1.1: Marine Processes Technical Annex for details). ***Scour effects*** The maximum design scenario for scour effects was based on the results of the scour assessment presented in Environmental Statement volume 5, annex 1.1: Marine Processes Technical Annex. Each foundation type may produce different scour patterns therefore monopiles, GBFs and jacket foundations were all considered. Suction caissons for jackets and monopiles were not explicitly assessed as they fall within the envelope of change of the other three foundation types.

Maintenance operations may result in temporary seabed disturbances and potential effects on benthic ecology.	Temporary habitat loss/disturbance over the lifetime of the project of up to 9,770,400 m^2 comprising:
	• Up to 5,508,000 m^2 as a result of up to 5,400 jack-ups over the 35 year design life for turbine component replacement and access ladder replacement events, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 5,400 x six x 170);
	• Up to 65,280 m^2 as a result of up to 64 jack-ups in total over the 35 year design life for offshore substation component replacements and J-tube repair/replacement events, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 64 x six x 170);
	• For array and interconnector cables:
	  ◦ Up to 340,000 m^2 due to up to 17 remedial burial events over the 35 year design life affecting up to 2 km of cable per event and a width of disturbance of up to 10 m (i.e. 17 x 2,000 m x 10 m); and
	  ◦ Up to 910,700 m^2 as a result of up to one cable repair event per year, over the 35 year design life, affecting up to 25,000 m^2 per repair event and requiring one jack-up per repair event assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 35 x 25,000 m^2 + (35 x six x 170 m^2)).
	• For export cables:
	  ◦ Up to 2,400,000 m^2 due to up to 15 remedial burial events over the 35 year design life affecting up to 2 km of cable per event and a width of disturbance of up to twice the water depth (i.e. 15 x 2,000 m x (two x 40 m)); and
	  ◦ Up to 546,420 m^2 as a result of up to 21 cable repair events over the 35 year design life, affecting up to 25,000 m^2 per repair event and requiring one jack-up per repair event assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 21 x 25,000 m^2 + (21 x six x 170 m^2)).
	The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.
		These parameters are considered to represent the likely maximum design scenario for the requirement for jack-up barge operations for all turbines and substations for the lifetime of Hornsea Three.
		No substantive maintenance works on the export cables in the Hornsea Three intertidal area is anticipated, only access will be required periodically as outlined to inspect the cable and for geophysical surveys. Though the burial depth of the cables will be designed so they will remain buried for the full lifetime of Hornsea Three and beyond, it will be necessary to bury the cables if erosion or other natural processes cause them to become exposed. The most appropriate means of reburying any exposed cables will be assessed on an ad-hoc basis but will be no more intrusive than those used during construction.

Potential impact	Maximum design scenario	Justification

Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	• Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC converter substations (or up to four offshore HVAC booster stations on the offshore cable corridor) and up to three offshore accommodation platforms;
	• Accidental pollution may also result from offshore refuelling for crew vessels and helicopters: i.e. up to 2,885 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 4,671 round trips by helicopter per year over the 35 year design life;
	• A typical turbine is likely to contain approximately up to 25,000 l of lubricants (hydraulic oil, gear oil and grease), 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel, 13,000 l of coolant and up to 6 kg of sulphur hexafluoride (SF6);
	• A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates.
	• Offshore fuel storage tanks:
	  • One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and
	  • One on each of the up to three offshore accommodation platforms for CTV fuel and each with a capacity of 210,000 l.
	• Potential leachate from zinc or aluminium anodes used to provide cathodic protection to the turbines. Potential contamination in the intertidal resulting from machinery use and vehicle movement.
		These parameters are considered to represent the maximum design scenario with regards to maximum number of turbines, vessel and vehicle movements, and machinery required, and therefore the maximum volumes of potential contaminants carried during operation and maintenance activities.

Table 4.2: Maximum design scenario considered for the assessment of potential impacts on marine mammals.

Potential impact	Maximum design scenario	Justification
Construction phase		

Underwater noise from foundation piling and other construction activities (e.g. drilling of piles) within the Hornsea Three array area has the potential to cause injury or disturbance to marine mammals.	**Maximum design scenario – Spatial extent: monopile foundations with concurrent piling**
	Up to 319 monopiles (300 turbine foundations and 19 foundations for other infrastructure and platform foundations).
	• Piling of up to 300 monopile foundations of 15 m diameter for turbines;
	• Piling of up to 19 monopile foundations, 15 m diameter, for substations and platforms including:
	  ○ Three offshore accommodation platforms;
	  ○ Twelve offshore transformer substations; and
	  ○ Four offshore HVAC booster stations located within the Hornsea Three offshore cable route corridor (HVAC transmission option only).
	• Absolute maximum design scenario hammer energy of up to 5,000 kJ, although typically the maximum hammer energy will be considerably less than this and the absolute maximum hammer energy (i.e. up to 5,000 kJ) would not be required at all locations;
	• Most likely maximum of 3,500 kJ (average maximum energy likely to be required at each piling location); and
	• Average hammer energy of 2,000 kJ (average hammer energy likely to result across all piling activity).
	• Absolute maximum design scenario of four hours piling duration per monopile (including 30 minute soft start);
	• Maximum total duration of actual piling is 1,276 (four x 319);
	• Piling within Hornsea Three array area could occur as a single piling scenario or a two concurrent piling scenario (at opposite ends of the site) with the maximum design <u>spatial</u> scenario being for concurrent piling. Concurrent piling will occur only for infrastructure located within the Hornsea Three array area and not for infrastructure located within the offshore HVAC booster station search area in which only a single vessel scenario is possible, although a concurrent scenario with one vessel piling in the HVAC booster station search area and within the Hornsea Three array area is possible;
	• Assumed that one monopile could be installed in each 24 hours period for single piling or up to two monopiles installed for concurrent piling, plus a 20% contingency allowance.
	• Therefore, maximum design spatial scenario (concurrent piling scenario for infrastructure located within the Hornsea Three array area and single piling scenario for infrastructure located within the offshore HVAC booster station search area) is 193.8 days which consists of:
	  ○ Hornsea Three array area: 189 days = (157.5 days piling for 300 turbines + three accommodation platforms + 12 offshore transformer substations) plus 20% contingency; and
	  ○ Hornsea Three offshore cable corridor: 4.8 days = (four days piling for four offshore HVAC booster stations) plus 20% contingency.
	• Foundation installation could occur over 2.5 years in up to two phases with a gap of up to three years between phases. This includes foundation installation for the offshore HVAC booster substations within the Hornsea Three offshore cable corridor which is expected to occur within an eight month piling phase.
		The maximum design **spatial** design scenario equates to the greatest <u>area</u> of effect from subsea noise at any one time during piling. The noise modelling used the frequency spectrum from a 7 m monopile, however, this is appropriate for also modelling 15 m monopiles as, at this scale, the overall noise output from the piling is controlled by the hammer energy used, adjusted by the length of the pile in contact with the water, rather than the size of the pile. Therefore, modelling a 7 m monopile also encompasses the extent of the noise profile from a 15 m monopile (see section 5.1.3.8 of Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report).
		The monopile foundation for the HVAC transmission option results in the maximum design scenario spatially as the offshore HVAC booster stations are located in the offshore cable corridor and therefore, spatially, are closer to sensitive areas for SAC species (harbour porpoise, harbour seal and grey seal).
		Two vessels piling concurrently at maximum spacing would result in the largest area of impact at any one time, whilst considering the degree of overlap with the areas of highest density for each species.
		Locations modelled for each species were therefore selected separately to reflect the maximum design scenario in terms of highest numbers potentially affected. For cetaceans this was the scenario of two vessels piling in the Hornsea Three array area and for seals this was for one vessel piling in the Hornsea Three array area and one vessel piling in the HVAC booster station search area.

Potential impact	Maximum design scenario	Justification
	Maximum design temporal: jacket foundations with single piling Up to 1,848 pin piles (1,200 for turbine foundations and 648 for other infrastructure and platform foundations) • Piling of up to 300 jacket foundations (four piles per foundation, each pin pile 4 m diameter) for turbines, with up to 1,200 piles (300 x four) in total; • Piling of up to 19 jacket foundations, up to 4 m diameter piles, for substations and platforms including: o Three offshore accommodation platforms, with up to 72 piles (three x 24) in total; o Twelve offshore transformer substations, with up to 288 piles (12 x 24) in total; and o Four offshore HVDC converter substations located in the Hornsea Three array area with up to 288 piles (four x 72 piles per foundation) in total (HVDC transmission option only). Maximum hammer energies defined as follows: • Absolute maximum hammer energy of up to 2,500 kJ (maximum that installation machinery is capable of); • Average maximum of 1,750 kJ (highest energy likely to be reached during piling events); and • Average hammer energy of 1,250 kJ (average hammer energy likely to be reached during piling). • Maximum four hours piling duration per pile (including 30 minute soft start); • Maximum total piling duration 7,392 hours of piling (four x 1,848); • Piling could occur as single vessel scenario or two concurrent vessels (at opposite ends of the site) although maximum design temporal scenario is for single piling; • Assumed that four pin piles could be installed in each 24 hour period, plus a 20% contingency; • Therefore, maximum design temporal scenario (single piling scenario for infrastructure located within the Hornsea Three array area only) is 554.4 days comprising: o 300 days piling for turbines (1,200 pin piles) o 18 days piling for accommodation platforms (72 pin piles) o 72 days for offshore transformer substations (288 pin piles) o 72 days for + for offshore HVDC converter substations (288 pin piles) o Total = 462 days plus 20% contingency. • Foundation installation could occur over 2.5 years in up to two phases (i.e. of ~1.25 years each phase) with a gap of up to three years between phases. ***Maximum design scenario*** • Clearance of up to 23 UXO across the Hornsea Three array area and offshore cable corridor.	The maximum design **temporal** scenario represents the longest duration of effects from subsea noise. This scenario assumes piled foundations again but this time for jackets as this could result in a longer duration of piling per foundation compared with monopiles. The HVDC transmission option results in the maximum design scenario temporally as the offshore HVDC converter substations (HVDC transmission option) requires a greater number of pin piles compared to the offshore HVAC booster stations (HVAC transmission option) and therefore would lead to a longer duration of piling. Scenario assumes longest duration of piling per pile (4 hours) and number of days piling is estimated assuming four pile jacket foundation installed per day. Single vessel piling is assumed as this would prolong the total number of days on which piling could occur within the 2.5 year piling phase (although noting that the piling phase itself has not actually increased under this scenario). Locations were selected for each species separately that would result in noise effects over the areas of highest density to ensure a precautionary approach was adopted. Locations modelled for each species to reflect a maximum design scenario in terms of highest numbers potentially affected.
Underwater noise from UXO clearance within the Hornsea Three array area has the potential to cause injury or disturbance to marine mammals.	Up to 23 UXO detonations throughout the Hornsea Three array area and offshore cable corridor prior to the start of construction. may be required. It is assumed that one UXO will be cleared in any 24 hour period, resulting in up to 23 days of UXO clearance (not including weather down time).	The characterisation surveys undertaken as part of the EIA process do not include surveys for detecting UXO and therefore the number of UXO that may need to be cleared prior to the start of construction for Hornsea Three is not currently known. However, based on the Hornsea Project One UXO clearance campaign undertaken in late 2017, for the purposes of this assessment it is assumed that the same number of UXO will need to be cleared for Hornsea Three as for Hornsea Project One due to the similarities in location and typical UXO found in the region. UXO clearance works will include locating and exposing the UXO and will be undertaken from a vessel by UXO specialist contractors. While some noise and minor localised increases in SSC will result from these investigative works, it is not expected that any impacts will arise from these effects, particularly compared to the clearance of the UXO.

Potential impact	Maximum design scenario	Justification
Increased vessel traffic during construction may result in an increase in disturbance to or collision risk with marine mammals.	Up to 126 construction vessels in the vicinity of the Hornsea Three array area (making up to 10,774 return trips for the construction phase, based on the following total number of construction vessel return trips): • Up to four installation vessels (300 return trips), up to 24 support vessels (1,800 return trips) and up to 12 transport vessels (900 return trips) for wind turbine installation; • Up to three installation vessels (300 return trips), up to 13 support vessels (1,500 return trips), up to 12 dredging vessels (1,200 return trips) and up to four transport vessels (tugs) (1,200 return trips) for wind turbine gravity base foundation installation; • Up to two installation vessels (38 return trips), up to 12 support vessels (228 return trips) and up to four transport vessels (38 return trips) for offshore substation foundations installation; • Up to three main cable laying vessels (315 return trips), up to three main cable burial vessels (315 return trips), support vessels comprising up to four crew boats or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, and up to two dredging vessels (1,890 return trips for support vessels) for array cable installation; • Up to four main cable laying vessels comprising up to one barge and three associated tugs (180 return trips), up to four main jointing vessels comprising up to one barge and three associated tugs (120 return trips), up to four main burial vessels support vessels comprising up to one barge and three associated tugs (180 return trips) and up to two crew boats or SOVs, up to one service vessels, up to one diver vessels, up to one PLGR vessels, and up to one dredging vessels (270 return trips for support vessels) for export cable installation; and • Up to eight vessels in a 5 km^2 area at any one time. A range of vessels (engine sizes and speeds) will be used during the construction phase, specified within the project description (Environmental Statement volume 1, chapter 3) include: self-propelled jack up vessels, jack up barges pulled by tugs, sheerleg barges, heavy lift vessels (HLV), dredging vessels, drilling vessels, crew transfer vessels, guard boats and cable installation vessels.	Maximum design scenario considers a wide range of vessel types likely to result in different noise signatures within the marine environment which may affect each identified marine mammal receptor differently (depending on their hearing sensitivity). The number of vessel movements was summed for each potential foundation type and gravity bases was found to have the greatest number of return vessel trips over the construction phase, although noting that the range of vessels required will be different for each foundation type. The maximum design scenario assumes that, for each of the different construction events listed, a summed total of the highest number of vessel movements is achieved. The summed total of the highest number of vessel movement during each construction event is considered to be the maximum design scenario for collision risk, although noting that some vessels, such as fast moving vessels, may pose a greater risk to marine mammals in terms of collision.
Accidental pollution released during construction (including construction activities, vessels, machinery and offshore fuel storage tanks) may lead to release of contaminants into the marine environment and subsequently result in potential effects on marine mammals.	Accidental pollution from synthetic compound, heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation particularly associated with up to 126 construction vessels in the vicinity of the Hornsea Three array area (making up to 10,774 return trips for the construction phase, based on the following total number of construction vessel return trips): • Up to four installation vessels (300 return trips), up to 24 support vessels (1,800 return trips) and up to 12 transport vessels (900 return trips) for wind turbine installation; • Up to three installation vessels (300 return trips), up to 13 support vessels (1,500 return trips), up to 12 dredging vessels (1,200 return trips) and up to four transport vessels (tugs) (1,200 return trips) for wind turbine gravity base foundation installation; • Up to two installation vessels (38 return trips), up to 12 support vessels (228 return trips) and up to four transport vessels (38 return trips) for offshore substation foundations installation; • Up to three main cable laying vessels (315 return trips), up to three main cable burial vessels (315 return trips), support vessels comprising up to four crew boats or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, and up to two dredging vessels (1,890 return trips for support vessels) for array cable installation; • Up to four main cable laying vessels comprising up to one barge and three associated tugs (180 return trips), up to four main jointing vessels comprising up to one barge and three associated tugs (120 return trips), up to four main burial vessels support vessels comprising up to one barge and three associated tugs (180 return trips) and up to two crew boats or SOVs, up to one service vessels, up to one diver vessels, up to one PLGR vessels, and up to one dredging vessels (270 return trips for support vessels) for export cable installation. Water-based drilling muds associated with drilling to install foundations, should this be required. A typical accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates. Offshore fuel storage tanks: • One tank on each of the up to three accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across all accommodation platforms; and • One on each of the up to three offshore accommodation platforms for crew transfer vessel fuel and each with a capacity of 210,000. Potential contamination of nearshore/intertidal habitats from drilling mud (bentonite) used to facilitate the installation of export cables in the intertidal via HDD.	These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction and the offshore storage of fuel.

Potential impact	Maximum design scenario	Justification
Operation phase		
Increased vessel traffic during operation and maintenance may result in an increase in disturbance to marine mammals.	Operation and maintenance vessels in the vicinity of the Hornsea Three array area making up to 2,885 return trips per year, comprised of: • jack-up vessels (140 return trips); • crew transfer vessels (2,433 return trips); and • supply vessels (312 return trips). Up to 3,785 return helicopter trips/year to wind turbines.	The maximum design scenario represents the maximum number of vessels and range of vessels likely to lead to disturbance.
Accidental pollution released during operation and maintenance (including maintenance activities, vessels, machinery and offshore fuel storage tanks) may lead to release of contaminants into the marine environment and subsequently result in potential effects on marine mammals.	Synthetic compounds (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC substations (or up to four offshore HVAC booster substations on the Hornsea Three offshore cable corridor) and up to three accommodation platforms. Accidental pollution may also result from offshore refuelling for crew vessels and helicopters (i.e. up to 2,822 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 4,671 round trips by helicopter per year over the 35 year design life). A typical turbine is likely to contain approximately 25,000 l of lubricants (hydraulic oil, gear oil and grease), 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel, 13,000 l of coolant and 6 kg of SF_6 A typical offshore transformer substation is likely to contain up to 50,000 l of diesel, up to 200,000 l of transformer oil and up to 1,500 kg of SF_6; A typical offshore HVDC substation is likely to contain up to 200,000 l of diesel; A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates. Offshore fuel storage tanks: • One tank on each of the up to three accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the Hornsea Three array area; and • One on each of the up to three accommodation platforms for crew transfer vessel fuel and each with a capacity of 210,000 l. Potential leachate from zinc or aluminium anodes used to provide cathodic protection to the turbines. Potential contamination in the intertidal resulting from machinery use and vehicle movement.	These parameters are considered to represent the maximum design scenario with regards to maximum number of turbines, vessel movements, and machinery required, and therefore the maximum volumes of potential contaminants carried during operation and maintenance activities

Table 4.3: Maximum design scenario considered for the assessment of potential impacts on offshore ornithology.

Potential impact	Maximum design scenario	Justification
Construction phase		
The impact of construction activities such as increased vessel activity and underwater noise, may result in direct disturbance or displacement from important foraging and habitat areas of birds.	**Maximum design scenario: Construction vessels** Up to 10,474 vessel movements during construction, comprised of: • Up to 3,900 vessel movements over construction period based on gravity base foundations (self-installing concept); • Up to 3,000 vessel movements, over construction period for Wind Turbine Generator (WTG) installation; • Up to 304 vessel movements over construction period for substations; • Up to 2,520 vessel movements over construction period for array cables; • Up to 750 vessel movements over construction period for export cable; and • Up to 8 vessels in a 5 km^2 area at any one time. ○ The installation of the offshore components of Hornsea Three will occur over a maximum duration of eight years, assuming a two phase construction scenario. A gap of three years may occur between the same activity in different phases. ○ Up to 3,785 helicopter flights per year comprising of: • 225 return trips associated with wind turbine installation; • 600 return trips associated with monopile installation; • 532 return trips associated with substation foundation construction • 1,828 return trips associated with export cable installation; and • 600 return trips associated with inter-array cable installation ○ **Maximum design scenario: Construction activity** The potential for disturbance / displacement impacts due to construction activity are considered for two different scenarios – maximum level of construction activity and maximum duration of construction activity. **Maximum construction activity level (magnitude)** Foundations when using monopiles with concurrent piling • Piling of up to 300 monopile foundations of 15 m diameter; • Piling of up to 19 monopile foundations, 15 m diameter, for substations and platforms including: ○ Three offshore accommodation platforms; ○ Twelve offshore transformer substations; and ○ Four offshore HVAC booster stations (located within the offshore HVAC booster station search area. • Total number of monopiles 319 (300 + 19); • Absolute maximum hammer energy of up to 5,000 kJ, although typically the maximum hammer energy will be considerably less than this and the absolute maximum hammer energy (i.e. up to 5,000 kJ) would not be required at all locations; • Average maximum of 3,500 kJ (highest energy likely to be reached during piling events); and • Average hammer energy of 2,000 kJ (average hammer energy likely to be reached during piling). • Maximum 4 hours piling duration per monopile (including 30 minute soft start); • Maximum total duration of actual piling 1,276 hours (4 x 319); • Piling within Hornsea Three array area singly or concurrently (a maximum of two vessels piling at opposite ends of the site) with the maximum design spatial scenario being for concurrent piling. Concurrent piling will occur only for infrastructure located within the Hornsea Three array area and not for infrastructure located within the offshore HVAC booster station search area in which only a single vessel scenario is possible;	**Maximum design scenario: Construction vessels** Maximum design scenario provides for the greatest number of potential vessels associated with the construction phase and hence the highest likelihood of potential disturbance/displacement to bird species, as a result of multiple activities taking place over an eight year offshore construction period. Maximum design scenario also reflects season and location with respect to a species abundance and vulnerability to an impact in the zone of influence i.e. seasonality distribution is considered as part of the sensitivity rating. **Maximum design scenario: Construction activity** Maximum Design Scenario provides for the greatest disturbance/displacement effects to bird species due to construction activities (magnitude and duration). **Maximum magnitude of piling** provides for the maximum increase in background noise levels generated over the largest area. Maximum diameter of pile and maximum number of simultaneous piling events provides for the maximum construction activity generated. Maximum separation distance provides the maximum spatial extent of construction activity impact (construction activity footprint area). All other foundation scenarios considered for WTGs (GBS, piled jackets and suction caisson jackets) would result in reduced levels of construction activity. **Maximum piling duration** provides for the maximum duration of disturbance / displacement to bird species. Maximum piling duration assumes active piling over 2.5 years over a six years construction period with piling being intermittent when using a two phase partially-parallel construction programme. All other foundation scenarios considered for WTGs (GBS, monopiles and suction caisson jackets) would result in reduced pile duration.

Potential impact	Maximum design scenario	Justification

	• Assumed that one monopile could be installed in each 24 hours period for single piling or up to two monopiles installed for concurrent piling, plus a 20% contingency allowance.
	• Therefore, maximum design spatial scenario (concurrent piling scenario for infrastructure located within the Hornsea Three array area and single piling scenario for infrastructure located within the offshore HVAC booster station search area) is 193.8 days which consists of:
	• Hornsea Three array area: 189 days = (157.5 days piling for 300 turbines + three accommodation platforms + 12 offshore transformer substations) plus 20% contingency; and
	• Hornsea Three offshore cable corridor: 4.8 days = (four days piling for four offshore HVAC booster stations) plus 20% contingency.
	• Foundation installation could occur over 2.5 years in up to two phases with a gap of up to three years between phases. This includes foundation installation for the offshore HVAC booster substations within the Hornsea Three offshore cable corridor which is expected to occur within an eight month piling phase.
	Offshore cables:
	• Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Individual elements of construction will be over shorter durations as follows: Installation of 1,146 km of export cables (six cable trenches 191 km in length) within the Hornsea Three offshore cable corridor and array area. 30 m width of disturbance per cable where sandwave clearance, 25 m for boulder clearance (15 m for array cables) and 15 m elsewhere with the exception of within the MCZ where clearance will be 10 m is necessary, elsewhere 10 m width of disturbance per cable.
	• Installation of up to 830 km of array cables, 225 km of platform inter-connector cables. Up to 30 m width of disturbance per cable where sandwave clearance is necessary
	Maximum design temporal: jacket foundations with single piling
	Up to 1,848 pin piles (1,200 for turbine foundations and 648 for other infrastructure and platform foundations)
	• Piling of up to 300 jacket foundations (four legs per foundation, each pin pile 4 m diameter) for turbines, with up to 1,200 piles (300 x 4) in total;
	• Piling of up to 19 jacket foundations, up to 4 m diameter, for substations and platforms including:
	  o Three offshore accommodation platforms (six legs), with up to 72 piles (three x 24) in total;
	  o Twelve offshore transformer substations (six legs), with up to 288 piles (12 x 24) in total; and
	  o Four offshore HVDC converter substations located in the Hornsea Three array area (72 piles per foundation) with up to 288 piles (four x 72) in total (HVDC transmission option only).
	• Maximum hammer energy of up to 2,500 kJ, although typically the maximum hammer energy will be considerably less than this, with only a proportion of the piles requiring the maximum hammer energy (i.e. up to 2,500 kJ);
	• Maximum four hours piling duration per pile (including 30 minute soft start);
	• Maximum total piling duration 7,392 hours of piling (four x 1,848);
	• Piling could occur as single vessel scenario or two concurrent vessels (at opposite ends of the site) although maximum design temporal scenario is for single piling;
	• Assumed that four pin piles could be installed in each 24 hour period for single piling, or up to eight pin piles installed for concurrent piling, plus a 20% contingency;
	• Therefore maximum design temporal scenario (single piling scenario for infrastructure located within the Hornsea Three array area only) is 554.4 days comprising:
	  o 300 days piling for turbines (1,200 pin piles)
	  o 18 days piling for accommodation platforms (72 pin piles)
	  o 72 days for offshore transformer substations (288 pin piles)
	  o 72 days for + for offshore HVDC converter substations (288 pin piles)
	  o Total = 462 days plus 20% contingency.
	• Foundation installation could occur over 2.5 years in up to two phases (i.e. of ~1.25 years each phase) with a gap of up to three years between phases.
	Offshore cables:	

<table>
<tr><th>Potential impact</th><th>Maximum design scenario</th><th>Justification</th></tr>
<tr><td></td><td>Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Individual elements of construction will be over shorter durations as follows: Installation of 1,146 km of export cables (six cable trenches 191 km in length) within the cable route corridor. 30 m width of disturbance per cable where sandwave clearance is necessary, elsewhere 10 m width of disturbance per cable.
Installation of up to 830 km of array cables, 225 km of platform inter-connector cables. 30 m width of disturbance per cable where sandwave clearance is necessary, elsewhere 10 m width of disturbance per cable.</td><td></td></tr>
<tr><td>Indirect effects, such as changes in habitat or abundance and distribution of prey.</td><td><u>Temporary habitat loss:</u>
Total subtidal temporary habitat loss of up to 68,645,736 m^2 and total intertidal temporary habitat loss of up to 271,914 m^2 comprising the following:
Hornsea Three array area - Foundations
1,301,520 m^2 temporary loss due to jack-up barge deployments for foundations for up to 319 structures (maximum design scenario assumes up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC substations and up to three offshore accommodation platforms) assuming six spud cans per barge, 170 m^2 seabed area affected per spud can and four jack up operations per turbine (319 foundations x 6 spud cans x 170 m^2 per spud can x 4 jack ups);
Up to a total of 4,235,774 m^2 of spoil from placement of coarse dredged material to a uniform thickness of 0.5 m (see justification, right) as a result of seabed preparation works prior to the installation of all GBFs. Comprising:
Up to a total of 1,225,800 m^3 of material from seabed clearance due to the installation of up to 300 turbines with GBFs (each with a seabed clearance volume of up to 4,086 m^3) affecting up to 2,451,600 m^2;
Up to a total of 735,000 m^3 of material from seabed clearance due to the installation of up to 12 offshore transformer substations with box GBFs (each with a seabed clearance volume of up to 61,250 m^3) affecting up to 1,470,000 m^2;
Up to a total of 139,552 m^3 of material from seabed clearance for up to four offshore HVDC convertor substations with box GBFs (each with a seabed clearance volume of up to 34,888 m^3) affecting up to 279,104 m^2; and
Up to a total of 17,535 m^3 of material from seabed clearance for up to three offshore accommodation platforms (each with a seabed clearance volume of up to 5,845 m^3) affecting up to 35,070 m^2.
Up to a total of 1,560,000 m^2 of temporary loss from the clearance of sandwaves prior to turbine installations.
Hornsea Three array area - Cables
Up to a total of 19,920,000 m^2 from burial of up to 830 km of array cables as follows:
Up to a total of 14,490,000 m^2 due to 498 km of the array cable requiring sandwave clearance (up to 30 m wide corridor); and
Up to a total of 4,980,000 m^2 due to boulder clearance and laying of up to 332 km of array cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
Up to a total of 6,300,000 m^2 from burial of up to 225 km of interconnector cables as follows:
Up to a total of 4,050,000 m^2 due to 135 km of the interconnector cable requiring sandwave clearance (up to 30 m wide corridor); and
Up to a total of 2,250,000 m^2 due to boulder clearance and laying of up to 90 km of interconnector cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
Up to a total of 4,704,000 m^2 from burial of up to 168 km of export cables (up to six trenches of 28 km length) within the array as follows:
Up to a total of 3,024,000 m^2 due to 100.8 km of the export cables within the array requiring sandwave clearance (up to 30 m wide corridor); and
Up to a total of 1,680,000 m^2 due to boulder clearance and laying of up to 67.2 km of interconnector cables by</td><td>The maximum design scenario is represented by the largest footprint from the foundation structures (and associated scour protection) under consideration and hence greatest influence on habitat and physical processes, created by greatest number of turbines etc.
<u>Temporary habitat loss:</u>
The maximum design scenario presented is associated with HVDC transmission due to the larger foundation sizes associated with the offshore HVDC substations compared to the HVAC booster substations.
Seabed preparation works prior to gravity base installation represents the maximum design scenario, with respect to spatial extent, for temporary habitat loss, compared to the temporary habitat loss associated with drill arisings resulting from jacket foundation installation.
The area affected by the placement of material as a result of seabed preparation and sandwave clearance has been calculated based on the maximum volume of sediment placed across the entire Hornsea Three array area, assuming all this sediment is coarse material and therefore is placed on the seabed (i.e. is not dispersed through tidal currents; see "Temporary increases in suspended sediment concentrations" impact assessment below). The total area of seabed affected was calculated assuming a mound of uniform thickness of 0.5 m height. As detailed in Environmental Statement volume 5, annex 1.1: Marine Processes Technical Report, the area of seabed affected by this scenario broadly aligns with the scenario of a cone shaped mound of 1.7 m maximum height (see Table 4.24 of Environmental Statement volume 5, annex 1.1). Temporary loss of benthic habitat is assumed beneath this within the Hornsea Three array area.
The maximum design scenario for temporary habitat loss has considered the burial of all subtidal cables, except where the necessary burial depth cannot be achieved.
Temporary habitat loss within the entire Hornsea Three offshore cable corridor and temporary working area at the landfall has been considered as the maximum design scenario (including anchor placements), though direct impacts (i.e. excavation) will only occur within a proportion of these areas.
Drilling operations for foundation installation: Greatest sediment disturbance from a single foundation location
Drilling of individual turbine monopile foundations results in the release of relatively larger volumes of relatively fine sediment, at relatively lower rates (e.g. potentially leading to SSC effects over a wider area or longer duration), than similar potential impacts for bed preparation via dredging for individual gravity base foundations (which are separately assessed).
The greatest volume of sediment disturbance by drilling, for both individual foundations and for the array as a whole, is associated with the largest diameter monopile and piled jacket foundations for substations in the array area.
The volume of sediment released through drilling of other turbine and offshore accommodation platform foundation types (e.g. piled jackets) is smaller than for monopiles.
The HVDC transmission system option (up to12 offshore transformer substations and up to four offshore HVDC converter substations) results in the largest number of offshore HVDC substation</td></tr>
</table>

Potential impact	Maximum design scenario	Justification

	trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
	• Up to a total of 142,300 m^2 from placement of coarse dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance within the Hornsea Three array, assuming a volume of up to 71,150 m^3, placed on the seabed within the Hornsea Three array area.
	• Up to a total of 244,600 m^2 from cable barge anchor placement associated with array, interconnector and export cable laying within the Hornsea Three array area assuming: one anchor (footprint 100 m^2) repositioned every 500 m ((830,000 m + 225,000 m + 168,000 m) x one x 100 m^2 / 500 m =244,600 m^2).
	Hornsea Three offshore cable corridor - Subtidal
	• Up to a total of 27,492,030 m^2 from burial of up to 978 km of export cable (up to six trenches of 163 km length) as follows:
	  ○ Up to a total of 18,396,180 m^2 due to 613.2 km of the export cable requiring sandwave clearance (up to 30 m wide corridor);
	  ○ Up to a total of 9,095,850 m^2 due to boulder clearance and cable laying of up to 363.8 km of export cable by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor for boulder clearance and 15 m wide corridor for cable installation).
	• Up to a total of 2,405,912 m^2 from placement of coarse, dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance on the offshore cable corridor, assuming a volume of up to 1,202,946 m^3, placed on the seabed within the Hornsea Three offshore cable corridor.
	• Up to 339,600 m^2 from cable barge anchor placement associated with cable laying for subtidal export cables within the Hornsea Three offshore cable corridor broken down as follows:
	  ○ First 20 km of the offshore cable corridor: Up to seven anchors (footprint of 100 m^2 each) repositioned every 500 m for up to six export cables (20,000 m x seven x 100 m^2 x six / 500 m = 168,000 m^2); and
	  ○ Export cables beyond 20 km: one anchor (footprint of 100 m^2) repositioned every 500 m for up to six export cables ((163,000 m – 20,000 m) x one x 100 m^2 x six / 500 m = 171,600 m^2).
	Hornsea Three offshore cable corridor - Intertidal
	• Up to 12,642 m^2 from works to bury up to 500 m of cable length (from MHWS to MLWS) with up to six cable circuits (i.e. up to 3 km of export cable in the intertidal) by trenching (assuming habitat loss/disturbance within the entire corridor width).
	Drilling operations for foundation installation: Greatest sediment disturbance from a single foundation location
	Total sediment volume of up to 581,611 m^3 comprising:
	• Up to 113,104 m^3 total spoil volume, from largest turbine monopile foundations (up to 160 monopiles), associated diameter 15 m, drilling to 40 m penetration depth, spoil volume per foundation 7,069 m^3, up to 10% of foundations may be drilled (160 x 10% x 7,069 m^3 = 113,104 m^3).
	• Up to 253,338 m^3 total spoil volume from largest offshore transformer substation piled jacket foundations (up to 12 foundations), 24 piles per foundation (six legs), 4 m diameter, drilling to 70 m penetration depth, spoil volume per foundation 21,112 m^3, up to 100% of foundations may be drilled (12 x 21,112 m^3 = 253,338 m^3).
	• Up to 193,962 m^3 total spoil volume from the largest offshore HVDC converter substation piled jacket foundations (up to four foundations), 72 piles per foundation (18 legs), 3.5 m diameter, drilling to 70m penetration depth, spoil volume per foundation 48,490 m^3, up to 100% of foundations may be drilled (four x 48,490 m^3 = 193,962 m^3).
	• Up to 21,207 m^3 total spoil volume from the largest offshore accommodation platform monopile foundations (up to three monopiles), associated diameter 15 m, drilling to 40 m penetration depth, spoil volume per foundation 7,069 m^3, up to 100% of foundations may be drilled (three x 7,069 m^3 = 21,207 m^3).
	Up to two foundations may be simultaneously drilled with a minimum spacing of 1,000 m.
	Disposal of drill arisings at the water surface.
		foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option.
		Dredging for seabed preparation for foundation installation: Greatest sediment disturbance from a single foundation location
		Dredging as part of seabed preparation for individual gravity base foundation foundations results in the release of relatively smaller overall volumes of relatively coarser sediment, at relatively higher rates (e.g. leading to higher concentrations over a more restricted area), than similar potential impacts for drilling of individual monopile or piled jacket foundations (which are separately assessed above).
		The greatest sediment disturbance from a single gravity base foundation location is associated with the largest diameter or dimension gravity base foundation, which results in the greatest volume of spoil from a single foundation. Due to differences in both scale and number, gravity base foundations for turbines, electrical substations and offshore accommodation platforms are separately considered.
		The HVDC transmission system option (up to12 offshore transformer substations and up to four offshore HVDC converter substations) results in the largest number of offshore HVDC substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option.
		Cable Installation
		Cable installation may involve ploughing, trenching, jetting, rock-cutting, surface laying with post lay burial, and/or surface laying installation techniques. Of these, mass flow excavation will most energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum design scenario for sediment dispersion.
		Sandwave clearance may involve dredging or mass flow excavation tools. Of these, mass flow excavation will most energetically disturb sediment in the clearance profile and as such is considered to be the maximum design scenario for sediment dispersion causing elevated SSC over more than a very short period of time. Dredging will result in a potentially greater instantaneous local effect in terms of SSC and potentially a greater local thickness of sediment deposition, but likely of a shorter duration and smaller extent, respectively.

Potential impact	Maximum design scenario	Justification

	Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Foundation installation over up to 2.5 years within this time.
	
	Dredging for seabed preparation for foundation installation: Greatest sediment disturbance from a single foundation location
	
	Total sediment volume of 1,827,287 m^3, comprising:
	• 935,000 m^3 total spoil volume from largest turbine GBF (up to 160 GBFs), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m^3 (160 x 5,845 = 935,000 m^3).
	• 735,000 m^3 total spoil volume from largest offshore transformer substation GBF (up to 12 GBFs), associated base dimensions 75 m, associated bed preparation area dimensions 175 m, average depth 2 m, spoil volume per foundation 61,250 m^3 (12 x 61,250 m^3 = 735,000 m^3).
	• 139,552 m^3 total spoil volume from largest offshore transformer substation GBFs (up to four GBFs), associated base dimensions 90 x 170 m, associated bed preparation area dimensions 98 x 178 m, average depth 2 m, spoil volume per foundation 34,888 m^3 (four x 34,888 m^3 = 139,552 m^3).
	• 17,535 m^3 total spoil volume from largest offshore accommodation platform GBF (up to three GBFs), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m^3 (three x 5,845 m^3 = 17,535 m^3).
	
	Disposal of material on the seabed within Hornsea Three.
	
	Dredging carried out using a representative trailer suction hopper dredger (11,000 m^3 hopper capacity with split bottom for spoil disposal). Up to two dredgers to be working simultaneously, minimum spacing 1,000 m.
	
	Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Foundation installation over up to 2.5 years within this time.
	
	<u>Cable Installation</u>
	
	Total sediment volume of 14,256,240 m^3, comprising:
	• Array cables
	    o Installation method: mass flow excavator;
	    o Total length 830 km;
	    o 4,980,000 m^3 total spoil volume from installation of up to 830 km cables in a V-shape trench of width = 6 m and depth =2 m (830 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 4,980,000 m^3); and
	    o 71,150 m^3 total spoil volume from sand wave clearance by dredging or mass flow excavation within the Hornsea Three array area (based on the Hornsea Three array area geophysical survey data combined with cable installation design specifications).
	• Interconnector cables
	    o Installation method: mass flow excavator;
	    o 15 in-project cables, total length 225 km; and
	    o 1,350,000 m^3 total spoil volume from installation of up to 225 km cables in a V-shape trench of width = 6 m and depth =2 m (225 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 1,350,000 m^3).
	• Export cables
	    o Up to six cable trenches; each 191 km in length (1,146 km in total);
	    o Installation method: mass flow excavator;
	    o 6,876,000 m^3 total spoil volume from installation of up to 1,146 km cables in a V-shape trench of width = 6 m and depth =2 m (6 x 191 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 6,876,000 m^3); and
	    o 979,090 m^3 total spoil volume from sandwave clearance via either a dredger or mass flow excavator within the Hornsea Three offshore cable corridor (based on the Hornsea Three offshore cable corridor geophysical survey data combined with cable installation design specifications).
	
	Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Individual elements of construction will be over shorter durations as follows:	

Potential impact	Maximum design scenario	Justification
	• Array cable installation over up to six months to 2.5 years; and • Export cable installation over up to four months to 3 years.	
The impact of pollution including accidental spills and contaminant releases which may affect species' survival rates or foraging activity.	Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation and up to 10,474 return trips during the construction phase: • Up to four installation vessels (300 movements), up to 24 support vessels (1,800 movements) and up to 12 transport vessels (900 movements) for wind turbine installation; • Up to 13 support vessels (1,500 movements), up to 12 dredging vessels (1,200 movements) and up to four transport vessels (tugs) (1,200 movements) for wind turbine GBF installation; • Up to two installation vessels (38 movements), up to 12 support vessels (228 movements) and up to four transport vessels (38 movements) for offshore substation foundations installation; and • Up to three main cable laying vessels (315 movements), up to three main cable burial vessels (315 movements), support vessels comprising up to four crew boats or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, and up to two dredging vessels (1,890 movements for support vessels) for array cable installation. • Up to three main cable laying vessels (180 movements), up to three main cable jointing vessels (120 movements), up to three main cable burial vessels (180 movements), support vessels comprising four crew boat or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, up to three dredging vessels and up to two survey vessels (270 movements) for export cable installation Water-based drilling muds associated with drilling to install foundations, should this be required; A typical wind turbine is likely to contain up to 25,000 litres (l) of lubricants (hydraulic oil, gear oil and grease), up to 80,000 l of nitrogen, up to 7,000 l of transformer silicon/ester oil, up to 13,000 l of coolants, up to 2,000 l of diesel fuel and up to 6 kg of SF6; A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates; Offshore fuel storage tanks: • One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and • One on each of the up to three offshore accommodation platforms for crew transfer vessel (CTV) fuel and each with a capacity of 210,000 l. • Potential contamination of nearshore/intertidal habitats from drilling mud (bentonite) used to facilitate the installation of export cables in the intertidal via HDD.	Parameters that create the greatest use of fuel, chemicals and hazardous waste offshore in the project area at any one time, that have the potential to spill into the marine environment. The accidental release of contaminants may directly affect birds or indirectly via their prey. Maximum vessel traffic movements will be associated with greatest turbine numbers (and associated infrastructure) and will cause highest risk of a pollution incident.
Operation phase		
The impact of physical displacement from an area around turbines (300) and other ancillary structures (up to twelve offshore transformer substations, up to three offshore accommodation platforms and four offshore transformer substations) during the operational phase of the development may result in effective habitat loss and reduction in survival or fitness rates.	Operation of maximum number of turbines (up to 300 WTGs), within the total wind farm array area of 696 km^2, with a minimum of 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms. Infrastructure placed up to the edge of Hornsea Three.	Provides for the maximum amount (spatial extent) of habitat loss due to physical displacement effects. For sensitive species, the wind farm as a whole will be avoided, whereas for others only individual turbines will be avoided while within the wind farm. Edge-weighted layout will potentially maximise area of sea rendered unavailable to birds.
The impact of indirect effects such as changes in habitat or abundance and distribution of prey.	Operation of maximum number of turbines (up to 300 WTGs). Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations, and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms.	Provides for the greatest area of habitat loss or creates the greatest area of habitat e.g. artificial reef.

Potential impact	Maximum design scenario	Justification
Mortality from collision with rotating turbine blades	Operation of maximum number of turbines (up to 300 WTGs). Rotor swept diameter up to a maximum of 185 m when the maximum number of turbines is used i.e. total rotor swept area for the project of 9.19 km^2, with the lowest rotor tip height of 34.97 m above the Lowest Astronomical Tide. Irregular distribution of the positioning of the foundations within the total wind farm array area of 696 km^2, with a minimum of 1,000 m spacing.	Greatest rotor swept area plus parameters that maximise collision risk and therefore mortality rates for all species as the surface area available for collision increases. This is the turbine layout with the largest combined rotor swept area and collision probability, the latter at its highest when turbines are at maximum rotor speed and at the lowest tip height.
The impact of barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration.	Operation of maximum number of turbines (up to 300 WTGs). Rotor swept diameter up to a maximum of 185 m. when the maximum of turbines is used. Irregular distribution of the positioning of the foundations within the total wind farm array area of 696 km^2, with a minimum of 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations, and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms,	Provides the maximum number of structures in the wind farm across the broadest front in relation to bird trajectory, to increase likelihood that birds will avoid individual turbines or the wind farm as a whole.
The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality.	Operation of maximum number of turbines (up to 300 WTGs). Rotor swept diameter up to a maximum of 185 m when the maximum number of turbines is used. Randomised distribution of the positioning of the foundations within the total wind farm array area of 696 km^2, with a minimum 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations, and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms. Lighting outward and not directional on all structures, maximised intensity and range to provide best visibility for aviation and shipping purposes. Red and white lighting, which has been shown to be more disorienting for migrating birds.	Provides the maximum number of structures in the wind farm, with maximum intensity and extent of red and white light sources to increase likelihood that birds will be attracted to structures and become disoriented or more susceptible to collision risk.
The impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of bird species.	Up to 2,822 vessel return trips per year during operation and maintenance, including crew vessels wind turbine visits (2,433 return trips per year), supply vessels accommodation platform visits (312 return trips per year) and jack-up vessels (77 return trips per year) over the operational design life of the project (i.e. 35 years). Up to 4,671 helicopter flights per year.	Option provides for the largest possible source of direct and indirect (prey species) disturbance from noise, vessel movements and other maintenance related activity over the longest time period.

Potential impact	Maximum design scenario	Justification
The impact of pollution including accidental spills and contaminant releases associated with maintenance or supply/service vessels which may affect species' survival rates or foraging activity.	Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC substations (or up to four offshore HVAC booster substations on the offshore cable corridor) and up to three offshore accommodation platforms. Accidental pollution may also result from offshore refuelling for crew vessels and helicopters: i.e. up to 2,822 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 4,671 round trips by helicopter per year over the 35 year design life; A typical turbine is likely to contain approximately up to 25,000 l of lubricants (hydraulic oil, gear oil and grease), 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel, 13,000 l of coolant and up to 6 kg of SF6; A typical offshore transformer substation is likely to contain up to 50,000 l of diesel, up to 200,000 l of transformer oil and up to 1,500 kg of SF6; A typical offshore HVDC substation is likely to contain up to 200,000 l of diesel; A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates; Offshore fuel storage tanks: One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and One on each of the up to three offshore accommodation platforms for crew transfer vessel fuel and each with a capacity of 210,000 l. Potential leachate from zinc or aluminium anodes used to provide cathodic protection to the turbines. • The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.	Parameters that create the greatest use of fuel usage, chemicals and hazardous waste offshore in the project area at any one time, that have the potential to spill into the marine environment. The release of contaminants may directly affect birds or indirectly via their prey. Maximum vessel traffic movements will be associated with greatest turbine numbers (and associated infrastructure) and will cause highest risk of a pollution incident.
Decommissioning phase		
The impact of direct disturbance and displacement due to underwater noise and vessel traffic may stop birds from accessing important foraging and habitat areas. The impact of indirect disturbance and displacement due to underwater noise and vessel traffic may stop prey species accessing important foraging and habitat areas.	Decommissioning of: • Up to 300 WTGs, 12 offshore transformer substations, three offshore accommodation platforms, four offshore HVDC substations or four offshore HVAC booster stations (located within the offshore HVAC booster substation search area; • Up to 1,146 km of export cable and 830 km array cables; and • Up to 10,474 vessel movements during the decommissioning phase. • Up to 3,785 helicopter return trips during the decommissioning phase	Provides for the largest possible noise over the greatest spatial extent of the Project Three site, over the largest temporal scale. The maximum number of vessel movements and helicopter round trips during the construction phase which may affect the available airspace for other users.
The impact of indirect effects such as changes in habitat or abundance and distribution of prey.	Decommissioning of: • Up to 300 WTGs, 12 offshore transformer substations, three offshore accommodation platforms, four offshore HVDC substations or four offshore HVAC booster substations (located within the offshore HVAC booster substation search area; • Up to 1,146 km of export cable and 830 km array cables; and • Up to 10,474 return vessel trips over the decommissioning phase.	Maximum footprint and hence greatest influence on physical processes, created by removal of greatest number of turbines. Impacts may be either positive or negative depending on habitat types created for prey species. The maximum number of vessel movements during the construction phase which may affect the available airspace for other users.
The impact of pollution including accidental spills and contaminant releases associated with removal of infrastructure and supply/service vessels may lead to direct mortality of birds or a reduction in foraging capacity.	Maximum design scenario is identical to that of the construction phase.	Maximum design scenario as per construction phase

Table 4.4: Maximum design scenario considered for the assessment of potential impacts on onshore ecology.

Potential impact	Maximum design scenario	Justification
Construction phase		
Potential for open cut trenching and installation of cables to cause loss of hedgerow habitat	<u>Hornsea Three landfall area</u> Open cut at the Hornsea Three landfall area including: • Up to 60,000 m² working area including compound and up to 1,500 m² from transition joint bays (based on 250 m² x 6). • Up to six cables. • Corridor width up to 240 m wide (comprising six cables (with installation area up to 15 m) plus up to 20 m separation between each cable. • Duration of trenching works: up to 12 weeks (two weeks per cable). <u>Hornsea Three onshore cable corridor</u> Construction activities within corridor measuring up to 4,400,000 m² (80 m x 55,000 m) including: • Up to 1,650,000 m² (5 m x 55,000 m x 6) from installation of up to six cable trenches; • On average 0.6 m stabilised backfill in each 2 m deep trench; • Up to 99,000 m² from jointing bays (based on 440 jointing bays (each jointing bay is 9 m x 25 m)); • Up to 2,970 m² from link boxes (based on 330 link boxes (each link box: is 3 m x 3 m)). Link boxes are permanent sub surface structures; • Up to 396,000 m² from installation of temporary haul road/access tracks (6 m x 66,000 m per phase); • The maximum duration of construction for all onshore elements of Hornsea Three would be eight years, which assumes construction across two phases with a three-year gap in-between. Up to two minor watercourses and drainage channels to be crossed via an open cut trenching method. The open cut cable crossing methodology is described in Environmental Statement volume 1, chapter 3: Project Description.	The maximum design scenario for habitat loss is the use of open cut techniques due to the greater footprint required, compared to HDD. Consequently, this would also be the maximum design scenario for habitat loss and severance impacts on GCN, reptiles, bats and badgers. The maximum design scenario for disturbance to surface water resources would result from the use of open cut, temporary bridging and culverts. The HVAC transmission represents the maximum design scenario due to the greater number of cables required as this would result in the largest possible area of disturbance to surface water resources. Consequently, this would also be the maximum design scenario for impacts on water voles and otters. The maximum design scenario for impacts arising from airborne pollutants is the use of open cut techniques due to the greater footprint required and, consequently, the greater area of excavation and soil disturbance, compared to HDD. This results in a consequent increase in the potential for dust impacts. The maximum design scenario for disturbance impacts to birds is the use of open cut techniques due to the greater area of habitat affected and, consequently, the larger area affected by construction activity, compared to HDD. The maximum design scenario for all of the above impacts on ecology associated with the onshore cable corridor is the HVAC transmission due to the greater number of cable trenches required and, therefore, the greatest area of land affected. The maximum design scenario in terms of the duration of these impacts would be the two-phase cabling operation, which would require impacts to occur twice in each location. In some cases (such as hedgerows), hedgerows would not be likely to become fully established and mature in the period between phases.
Potential for open cut trenching and installation of cables to cause loss, damage to and disturbance of woodland		
Potential for open cut trenching and installation of cables leading to habitat loss and/or severance for GCN		
Potential for open cut trenching and installation of cables leading to habitat loss and/or severance for reptiles		
Potential for open cut trenching and installation of cables to cause disturbance to bats		
Potential for open cut trenching and installation of cables to cause habitat loss and disturbance to badgers		
Potential for open cut trenching and installation of cables to cause loss, damage to and disturbance of watercourses		
Potential for open cut trenching and installation of cables to cause damage to designated sites from runoff pollutants		
Potential for open cut trenching and installation of cables to cause damage to habitats from runoff pollutants		
Potential for open cut trenching and installation of cables to cause disturbance to water voles		
Potential for open cut trenching and installation of cables to cause disturbance to otters		
Potential for open cut trenching and installation of cables to cause damage to designated sites from airborne pollutants		
Potential for open cut trenching and installation of cables to cause damage to habitats from airborne pollutants		
Potential for open cut trenching and installation of cables to cause disturbance to birds that are designated features of the North Norfolk Coast SPA/Ramsar		
Potential for open cut trenching and installation of cables to cause disturbance to other wintering birds that are designated features of the North Norfolk Coast SPA/Ramsar		
Potential for open cut trenching and installation of cables to cause disturbance to breeding birds		
Potential for permanent habitat loss from construction of onshore infrastructure have adverse impacts on habitats	<u>Onshore HVDC converter/HVAC substation</u> Up to 149,302 m² for permanent area of site (including an area which may be used for landscaping) plus a temporary works area of approximately 70,000 m². Maximum building footprint 22,500 m² (based on HDVC converter station (two buildings each 75 m x 150 m)).	The HVAC transmission option represents the maximum design scenario for affecting ecological receptors due to the potential need for the onshore HVAC booster station resulting in the greatest area of habitat loss and disturbance. The onshore HVDC converter station represents the maximum design scenario as this has the greatest number of buildings and largest footprint and therefore, the largest potential for habitat loss and disturbance.
Potential for permanent habitat loss from construction of onshore infrastructure to have adverse impacts on species		
Potential for permanent habitat loss from construction of onshore infrastructure to have		

Potential impact	Maximum design scenario	Justification
adverse impacts on wintering birds	Onshore HVAC booster station Up to 30,407 m^2 for permanent area of site plus a temporary works area up to 25,000 m^2. Maximum building footprint of 9,000 m^2 (based on single building scenario (125 m length and 75 m width) and height up to 12.5 m).	
Potential for HDD beneath watercourses to cause damage and disturbance to designated sites	• Up to 120 HDD locations per phase (up to 105 minor HDDs and 15 major HDDs per phase), including 15 HDD compounds. Contamination via runoff from works as a result of spillages at HDD works.	HDD under designated sites is part of designed-in mitigation to avoid direct impacts from open trenching in designated sites. Therefore, the maximum design scenario for impacts on designated sites and habitats would result from the risk of HDD techniques indirectly contaminating surface watercourses or other sensitive habitats where they are hydraulically connected with surface runoff caused by spillages and the movement of sediment.
Potential for HDD beneath watercourses to cause damage and disturbance to other watercourses and habitats		
Potential for HDD beneath watercourses to cause habitat loss and disturbance to protected species		HDD under habitats of ecological value such as watercourses and woodlands is part of designed-in mitigation to avoid direct impacts from open trenching on these habitats. Therefore the maximum design scenario for effects on habitats and associated species would result from the risk of HDD crossing techniques indirectly contaminating surface watercourses or other sensitive habitats where they are hydraulically connected with surface runoff caused by spillages and the movement of sediment, and by disturbance impacts during construction.
Potential for construction of onshore infrastructure to have adverse impacts on designated sites from airborne pollutants	Onshore HVDC converter/HVAC substation Up to 149,302 m^2 for permanent area of site (including an area which may be used for landscaping) plus a temporary works area of approximately 70,000 m^2. Maximum building footprint 22,500 m^2 (based on HDVC converter station (two buildings each 75 m x 150 m)). Onshore HVAC booster station Up to 30,407 m^2 for permanent area of site plus a temporary works area up to 25,000 m^2. Maximum building footprint of 9,000 m^2 (based on single building scenario (125 m length and 75 m width) and height up to 12.5 m).	The maximum design scenario in terms of ecological effects arising from the onshore HVAC booster station is associated with the HVAC transmission as the booster station is not required for the HVDC transmission. The maximum design scenario in terms of ecological effects at the onshore HVDC converter/HVAC substation is the HVDC transmission as it requires the largest footprint for single and multiple building options resulting in the largest possible area of disturbance and, therefore, greatest potential for runoff or airborne pollutants.
Potential for construction of onshore infrastructure to cause damage to designated sites from runoff pollutants		
Potential for construction of onshore infrastructure to have adverse impacts on habitats from airborne pollutants		
Potential for construction of onshore infrastructure to cause damage to habitats from runoff pollutants		
Potential for temporary habitat loss from construction of construction compounds to have adverse impacts on habitats	Temporary compounds in locations as described in Environmental Statement volume 1, chapter 3: Project Description • Up to 120 HDD locations per phase (up to 105 minor HDDs and 15 major HDDs per phase), including 15 HDD compounds. • Up to 99,000 m^2 from jointing bays (based on 440 jointing bays (each jointing bay is 9 m x 25 m)).	The maximum design scenario in terms of the duration of impacts/number of occurrences would be the two-phase cabling operation, which would require HDD in each phase. HDD is part of designed-in mitigation to avoid direct impacts from open trenching for key receptors. The maximum design scenario would be the HVAC transmission option due to the greater number of cable trenches required (and therefore the greater number of HDDs, jointing bays etc).
Potential for construction of construction compounds to have adverse impacts on designated sites from airborne pollutants		
Potential for construction of temporary compounds to cause damage to designated sites from runoff pollutants		
Potential for construction of temporary construction compounds to have adverse impacts on habitats from airborne pollutants		
Potential for construction of temporary compounds to cause damage to habitats from runoff pollutants		
Potential for temporary habitat loss from construction of construction compounds to have adverse impacts on species		
Potential for temporary habitat loss from construction of construction compounds to have adverse impacts on wintering birds		
Potential for temporary habitat loss from construction of access tracks to have adverse impacts on designated sites	• Up to 396,000 m^2 from installation of temporary haul road/access tracks (6 m x 66,000 m per phase); • Roadway construction soil stabilisation.	The maximum design scenario in terms of the duration of impacts/number of occurrences would be the two-phase cabling operation, which would require temporary haul routes for each phase.
Potential for temporary habitat loss from construction of access tracks to have adverse		

<table>
<tr><th>Potential impact</th><th>Maximum design scenario</th><th>Justification</th></tr>
<tr><td>impacts on habitats</td><td rowspan="8"></td><td rowspan="8">The maximum design scenario in terms of the construction of haul roads would be the use of soil stabilisation techniques as this would be more difficult to remove and restore habitat post construction. The use of soil stabilisation also represents the maximum design scenario as it has the greatest potential for pollutants in runoff and airborne pollutants during the soil mixing process.</td></tr>
<tr><td>Potential for construction and use of access tracks to have adverse impacts on designated sites from airborne pollutants</td></tr>
<tr><td>Potential for construction and use of access tracks to cause damage to designated sites from runoff pollutants</td></tr>
<tr><td>Potential for construction and use of access tracks to have adverse impacts on habitats from airborne pollutants</td></tr>
<tr><td>Potential for construction and use of access tracks to cause damage to habitats from runoff pollutants</td></tr>
<tr><td>Potential for temporary habitat loss from construction of access tracks to have adverse impacts on species</td></tr>
<tr><td>Potential for temporary habitat loss and disturbance from construction and use of access tracks to have adverse impacts on wintering pink-footed goose</td></tr>
<tr><td>Potential for temporary habitat loss and disturbance from construction and use of access tracks to have adverse impacts on wintering birds</td></tr>
<tr><td colspan="3">Operational and maintenance phase</td></tr>
<tr><td>Potential for operation to result in low-level visual disturbance, and noise and vibration disturbance of habitats and species during routine maintenance operations</td><td rowspan="2">Inspections of HVAC booster station or onshore HVDC converter/HVAC substation: Weekly. Light vehicles; HVAC booster station may be less frequent.
Preventative Maintenance (routine service): Up to quarterly. Light vehicles; Typically, annually for main servicing, however servicing may be divided in to separate campaigns.
Corrective Maintenance: As required. Component driven; Major repairs could require outsize loads.</td><td rowspan="2">An onshore HVAC booster station would also be required for the HVAC transmission in addition to a HVAC substation and therefore, represents the maximum design scenario, which would also require maintenance.
The maximum design scenario at the onshore HVDC converter/HVAC substation would be the HVDC transmission as it has the biggest building footprint and area of impermeable surfacing.
The maximum design scenario for potential contamination of habitats and watercourses during operation is that chemicals and oils would be used in the routine maintenance of the onshore HVDC converter/HVAC substation.</td></tr>
<tr><td>Potential for operation to result in potential contamination of habitats and watercourses through accidental spillage of chemicals or fuels during routine maintenance operations, and/or increased sedimentation as a result of physical disturbance of soils</td></tr>
<tr><td colspan="3">Decommissioning phase</td></tr>
<tr><td>Potential for decommissioning of cables to affect designated sites</td><td rowspan="6">Depending on landowner requirements, the onshore HVDC converter/HVAC substation and HVAC booster station hardstanding would be removed as part of a decommissioning process to a desired depth that would allow a return to grazing if required. The future use of the land would be agreed with the local planning authority (LPA) or relevant authority at that time.
Buried cables would be de-energized with the ends sealed and left in place to avoid ground disturbance unless removal is required by the landowner.</td><td rowspan="6">The maximum design scenario during decommissioning is the removal of the link boxes, onshore HVDC converter/HVAC substation and onshore HVAC booster station as this presents the greatest disturbance and potential risk of sediment and contaminants being released.
The removal of the link boxes during decommissioning represents the maximum design scenario as this would result in disturbance of land along the onshore cable corridor.</td></tr>
<tr><td>Potential for decommissioning of cables to affect habitats</td></tr>
<tr><td>Potential for decommissioning of cables to affect species</td></tr>
<tr><td>Potential for decommissioning of HVAC booster station and onshore HVDC converter/HVAC substation to affect designated sites</td></tr>
<tr><td>Potential for decommissioning of HVAC booster station and onshore HVDC converter/HVAC substation to affect habitats</td></tr>
<tr><td>Potential for decommissioning of onshore HVDC converter/HVAC substation and HVAC booster station to affect species</td></tr>
</table>

4.3 Project designed-in mitigation

4.3.1.1 As part of the project design process, a number of designed-in measures have been proposed to reduce the potential for impacts on European Site qualifying features. This approach has been employed in order to demonstrate commitment to measures by including them in the design of Hornsea Three and have therefore been considered in the assessments presented in this RIAA. These measures are considered standard industry practice for this type of development. Relevant designed-in mitigation measures relating to benthic Annex I habitats, Annex II marine mammals, offshore ornithology and onshore European Site qualifying features are detailed below in Table 4.5 to Table 4.8.

Table 4.5: Designed-in measures adopted as part of Hornsea Three – offshore benthic Annex I habitats.

Measures adopted as part of Hornsea Three	Justification
A pre-construction survey will be undertaken along the Hornsea Three offshore cable corridor to determine the location, extent and composition of any Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs. Should such reef features be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features, where possible, and on the basis of the extent of these features at the time of construction. This approach is typical for offshore wind farm and cable developments. Should Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs be identified within the temporary working corridor, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these features (e.g. from disposal of sandwave clearance material).	*S. spinulosa* reefs are known to occur within this part of the southern North Sea benthic ecology study area. Within the Hornsea Three array however, no biogenic or geogenic reefs were identified. Within the Hornsea Three offshore cable corridor, *S. spinulosa* aggregations assessed as being 'low reef' and 'medium reef' were identified. These terms are defined in Environmental Statement volume 2, chapter 2). Of these, only the station assessed as 'medium reef' (located just outside the North Norfolk Sandbanks SAC) was determined to potentially represent *S. spinulosa* reef. Direct impacts (e.g. habitat loss) to ecologically sensitive Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs are to be avoided where possible. Given the evidence for the propensity for reef to develop in this area, pre-construction surveys will be used to identify the presence of such reefs and ensure that measures can be designed, if necessary, to avoid direct impacts where possible.
In the event that the primary mitigation (i.e. avoiding Annex I reefs within SACs and/or biogenic or geogenic reefs outside SACs within the Hornsea Three offshore cable corridor, where possible) fails and export cables need to be installed through an area of reef(s), the cables would be microsited through areas of lower quality reef, avoiding areas of medium or high quality reef and/or cable installation would be restricted to the periphery of reef features to ensure continuous reef features are not bisected. To facilitate this, as more data on potential future Annex I *S. spinulosa* reefs within the North Norfolk Sandbanks and Saturn Reef SAC becomes available (e.g. JNCC reefs layer based on the results of the 2016 joint JNCC/Cefas survey within the Saturn reef (Mcllwaine *et al*., 2017) and Hornsea Three pre-construction surveys data), the Reef Index will be recalculated and used to inform cable routing in the North Norfolk Sandbanks and Saturn Reef SAC.	Where cable installation within Annex I reefs is unavoidable (e.g. due to practical or engineering constraints), further mitigation will be employed to minimise effects on reefs. This will be undertaken on the basis of the extent of these features at the time of construction which will be informed by the most up-to-date Reef Index calculations and core reef assessment prior to construction.
A PEMMP will be developed and implemented to cover the construction and operation and maintenance phases of Hornsea Three. The PEMMP will include planning for accidental spills, contain a biosecurity plan (see below) to limit the spread INNS, address all potential contaminant releases and include key emergency contact details (e.g. the Environment Agency (EA), Natural England and MCA). A Decommissioning Programme will be developed to cover the decommissioning phase.	Measures will be adopted to ensure that the potential for release of pollutants from construction, operation and decommissioning plant is minimised. These will likely include: designated areas for refuelling where spillages can be easily contained; only using chemicals included on the approved Cefas list under the Offshore Chemical Regulations 2002; storage of these in secure designated areas in line with appropriate regulations and guidelines; double skinning of pipes and tanks containing hazardous substances; and storage of these substances in impenetrable bunds. In this manner, the potential for release of contaminants from rigs and supply/service vessels will be strictly controlled, thus providing protection for marine life across all phases of the offshore wind farm development.
A Biosecurity Plan will be produced and agreed in consultation with statutory consultees	A document detailing how the risk of potential introduction and spread of INNS will be minimised is to be produced. This will include measures for cable/scour protection in the unlikely event that this material is sourced from the marine environment (it is anticipated that this material will originate from non-marine sources). The plan will outline measures to ensure vessels comply with the International Maritime Organization (IMO) ballast water management guidelines, it will consider the origin of vessels and contain standard housekeeping measures for such vessels as well as measures to be adopted in the event that a high alert species is recorded.
Hornsea Three will employ sensitive cable and scour protection within the areas of designated sites that coincide with Hornsea Three. These cable and scour protection measures will not include concrete mattresses. The cable and scour protection will consider the local seabed conditions, including sediment/substrate type. Within the designated sites this may include measures as follows: • Within the North Norfolk Sandbanks and Saturn Reef SAC: this may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes known to occur naturally within the SAC (i.e. coarse gravel, cobbles and boulders); • Within The Wash and North Norfolk Coast SAC: this may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes known to occur naturally within the SAC (i.e. coarse gravel and cobbles); Cable protection requirements will be detailed in the Cable Specification and Installation Plan and scour protection requirements will be detailed in the Scour Protection and Management Plan which will be produced prior to construction and agreed in consultation with statutory consultees.	It is anticipated that the use of such material may encourage the burial of the scour/cable protection by the surrounding sediment, which may serve to reduce any potential effect of long term habitat loss. Where such measures can be employed, local communities associated with the habitat features of designated sites (i.e. infaunal communities where sediment accumulation occurs; epifaunal communities in the case of appropriate cable protection) are likely to colonise these areas, potentially providing some limited recovery of communities in areas where cable protection is placed and reducing the extent of long term habitat loss. These measures have been adopted as a result of discussions with the EWG regarding the impacts to designated sites associated with cable protection requirements, rather than as a result of concerns about cable protection requirements for Hornsea Three per se.

Table 4.6: Designed-in measures adopted as part of Hornsea Three – marine mammals.

Measures adopted as part of Hornsea Three	Justification
A PEMMP (construction and operation phases) and Decommissioning Plan (decommissioning phase) will be produced and followed. The PEMMP and Decommissioning Plan will cover the construction, operation and maintenance, and decommissioning phases of Hornsea Three respectively and will include a Marine Pollution Contingency Plan (MCMP). This MCMP will outline procedures to protect personnel working and to safeguard the marine environment in the event of an accidental pollution event arising from offshore operations relating to Hornsea Three. The MPCP will also outline mitigation measures should an accidental spill occur, address all potential contaminant releases and include key emergency contact details (e.g. Environment Agency, Natural England and MCA).	Measures will be adopted to ensure that the potential for release of pollutants from construction, operation and maintenance, and decommissioning plant is minimised. In this manner, accidental release of potential contaminants from rigs and supply/service vessels will be strictly controlled, thus providing protection for marine life across all phases of the wind farm development.
Array, export and interconnector cables will typically be buried to a target burial depth of 1 to 2 m, subject to a cable burial risk assessment. Where it is not possible to ensure that cables will remain buried, cable protection will be installed.	While burial of cables will not reduce the strength of EMF, it does increase the distance between cables and fish and shellfish receptors, thereby potentially reducing the effect on those receptors.
During piling operations, soft starts will be used, with lower hammer energies (i.e. approximately 15% of the maximum hammer energy; see Environmental Statement volume 2, chapter 4) used at the beginning of the piling sequence before increasing energies to the higher levels.	The soft-start will provide an audible cue to allow marine mammals to flee the area before piling at full hammer energy commences. The soft/slow-start will help to mitigate any potential auditory injury.
A MMMP, approved by the MMO in consultation with Natural England will be implemented during construction. The MMMP will use acoustic deterrent devices (ADDs) as the primary mitigation measure prior to soft start to ensure marine mammals are deterred. The details of the MMMP will be agreed with Natural England.	The use of an approved MMMP will mitigate for the risk of physical or permanent auditory injury to marine mammals within a 'mitigation zone'. The mitigation zone was determined based on the potential for instantaneous auditory injury based on the initial hammer strike at 15% of the maximum hammer energy (soft-start hammer energy).
Codes of conduct for vessel operators including advice to operators to not deliberately approach marine mammals and to avoid abrupt changes in course or speed should marine mammals approach the vessel to bow-ride, will be issued to all Hornsea Three vessel operators and adhered to at all times.	To minimise the potential for collision risk or potential injury to, marine mammals.
A UXO specific MMMP, approved by the MMO in consultation with Natural England will be implemented during UXO clearance. The UXO MMMP will use ADDs, marine mammal observers and scare charges as the primary mitigation measures alongside other measures as may be agreed with Natural England and the MMO.	The use of an approved MMMP will mitigate for the risk of physical or permanent auditory injury and disturbance to marine mammals within a 'mitigation zone'.

Table 4.7: Designed-in measures adopted as part of Hornsea Three – offshore ornithology.

Measures adopted as part of Hornsea Three	Justification
Relevant HSE procedures will be followed for all activities during construction, operation and maintenance, and decommissioning periods.	When using consumables that are potentially hazardous, or refuelling offshore, relevant HSE procedures will be followed, with the objective of mitigating any risk of pollution incidents.
A PEMMP will be produced and followed. The PEMMP will cover the operation and maintenance phase of Hornsea Three and will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g. Environment Agency, Natural England and Maritime and Coastguard Agency). A Decommissioning Programme will be developed to cover the decommissioning phase..	Measures will be adopted to ensure that the potential for release of pollutants from construction, operation and maintenance, and decommissioning plant is minimised. In this manner, accidental release of contaminants from rigs and supply/service vessels will be strictly controlled, thus providing protection for birds and their prey species across all phases of the wind farm development.
Installation of appropriate lighting on wind farm structures.	Lighting of wind turbines will meet minimum requirements, namely as set out in the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation O-117 on 'The Marking of Offshore Wind Farms' for navigation lighting and by the Civil Aviation Authority in the Air Navigation Orders (CAP 393 and guidance in CAP 764). In keeping with the minimum legal requirements, this will minimise the risks of migrating birds becoming attracted to, or disorientated by turbines at night or in poor weather.
A minimum wind turbine hub-height of 127.47 m (above LAT) will be used for Hornsea Three. This provides for a lower blade tip height clearance of 34.97 m LAT.	This hub-height is considered appropriately conservative so as to minimise the risk of bird collisions.

Table 4.8: Designed-in measures adopted as part of Hornsea Three – onshore ecology.

Measures adopted as part of Hornsea Three	Justification
Design measures	
Use of HDD installation method beneath watercourses and designated sites, as detailed below (under Construction measures), including the River Wensum SAC.	To minimise the impact of construction on features of ecology and nature conservation value.
Where practicable, existing highways or tracks will be used for access to the construction site.	To minimise loss and disturbance of species and habitats.
The Hornsea Three onshore cable corridor has been developed to avoid designated sites, areas of woodland and other ecologically sensitive habitats wherever practicable.	To minimise loss of habitats of conservation interest.
Other VER features such as ponds have been avoided in the selection of the onshore cable corridor alignment and local features such as standard trees and hedgerows have been avoided where it has been practicable to do so.	
Where practicable, areas identified as containing protected species, including badgers and roosting bats, have been protected by siting the onshore cable corridor alignment to provide an appropriate buffer from construction and operational works. The width of these buffer zones will be developed in accordance with standard industry requirements and best practice guidance, and are expected to be applied for nesting birds, roosting bats, for active badger setts, for otter holts and resting places and for water vole colonies.	To reduce impacts on protected or otherwise notable species.
Pre-construction measures	
Pre-construction surveys, informed by existing data for protected species, will be carried out to identify potential changes in baseline conditions. These surveys will be undertaken within twelve months prior to the commencement of construction works. Surveys may need to be undertaken over several months in order to collate sufficient data to inform a licence application and any associated mitigation strategy. As the construction of the onshore cable corridor will be undertaken as a phased programme, surveys will be completed during the appropriate survey season (according to relevant guidance) and in accordance with the construction programme prior to construction. Should the twelve month survey/activity period lapse between pre-construction surveys and the commencement of works, the need to repeat surveys will be assessed by an appropriately experienced ecologist. Should surveys confirm a change in baseline conditions, which result in the need for an EPS licence, a licence will be obtained prior to the commencement of licensable works. Natural England typically requires up to 30 working days to process and consider a licence application and potential amendment requests may result in a longer processing period. Any licenced works will be supervised and/or carried out by an appropriately qualified, experienced and, where necessary, licensed ecologist, in accordance with the licence requirements.	To provide up to date information to ensure compliance with legal requirements and, where relevant, trigger the implementation of mitigation measures set out in the PEMMP.
Surveys will include pre-construction surveys (in line with the appropriate methodology to establish presence / absence as per previous surveys) (Environmental Statement volume 6, annex 3.5: Great Crested Newt Survey) of ponds that were not surveyed during 2017 and any ponds surveyed more than two years prior to construction that are located up to 250 m from the works area, subject to land access agreements, to establish presence/likely absence of GCN. The survey will include an initial HSI assessment to determine the need for presence/absence surveys. If GCN are present, these ponds will be included in the mitigation strategy and if necessary, an EPS licence will be obtained for works to commence. If access to survey is not granted, a worst case scenario will be assumed (i.e. that GCN are present) and these inaccessible ponds will be included in the mitigation plan.	To minimise the potential impacts on GCN.
Where reptile habitat is required to be cleared for construction, a detailed method statement will be developed in order to help ensure the protection of these species. The method statement will include detailed pre-construction measures designed to ensure that impacts on reptiles are minimised, through relocation of animals from the works corridor and an adjacent buffer zone and post-construction habitat reinstatement. The method statement will include post-construction habitat restoration and management requirements.	To help ensure the protection of reptiles.

Measures adopted as part of Hornsea Three	Justification
Where trees, hedgerows or scrub, of potential value to nesting birds, are required to be cleared for construction, clearance will be undertaken outside of the bird breeding season (14 February to 31 August inclusive) to prevent disturbance to nesting birds where possible. However, if this is not practicable, habitat will be surveyed prior to clearance. No habitat containing an active nest will be removed or disturbed, and measures will be set in place to protect the nest until young have fully fledged and left the nest. Measures may include the establishment of 5 m wide buffer zones in which heavy vehicles will not be tracked and the storage of vehicles, equipment, machinery and soil storage will be prohibited. Works in the buffer zone will be delayed until the Ecological Clerk of Works (ECoW) has confirmed young have fully fledged and left the nest. Ground-nesting birds may be deterred from suitable fields (> 5 ha, open fields) where HDD installation launch pits will be located, using bird scarers during the breeding season (no bird scarers will be employed in February in areas from Kelling to the landfall where wintering pink-footed geese might be affected).	To help ensure the protection of breeding birds and their young.
A pre-construction badger survey of the works area and 30 m buffer zone, or 100 m where HDD installation is to be undertaken, will be undertaken in order to locate any potential new active setts that could cause a constraint to construction. If mitigation cannot be carried out to protect the sett as required under legislation, then a Natural England licence to close or disturb the sett may be required and will be obtained prior to the commencement of works as necessary. Surveys will also be carried out in order to identify signs of high levels of activity, to inform the need for measures described under Construction measures below to be carried out to protect foraging badgers.	To help ensure the protection of badgers.
A pre-felling check of mature trees will be undertaken to confirm the absence of roosting bats, or a bat roost. Removal or pruning of a tree containing a bat roost, or significant disturbance or obstruction to bats or their roost will require an EPS licence for bats from Natural England, which will be obtained prior to the commencement/continuance of works that could affect the roost.	To help ensure the protection of bats.
Pre-construction studies will be carried out to identify sensitive habitats in the vicinity of large/sensitive watercourse crossing locations and plans developed for the establishment of associated construction compounds and works sites, to minimise potential impacts.	To minimise the likely impacts on ecology and nature conservation features of interest.
Construction measures	
All relevant mitigation measures will be implemented through the CoCP. An Outline CoCP accompanies the application for development consent.	To minimise the likely impacts on ecology and nature conservation features of interest, including biosecurity measures to prevent spread of invasive species.
Site induction and toolbox talks will include mitigation requirements included in this chapter and in the Outline EMP.	To help ensure adherence to the ecology mitigation strategy and protection of habitats and species of nature conservation interest.
All works will be carried out taking full account of legislative requirements and EA guidance.	To minimise the likely impacts on ecology and nature conservation features of interest.
Appropriate and adequate measures will be set in place to ensure appropriate levels of dust control to ensure, as far as practicable, that no significant off-site dust effects will occur.	
Vehicle speeds will be restricted within the working corridor.	To minimise the risk of collision with animals.
Heavy machinery will not be tracked on waterlogged soils or over stored soils. Soil storage areas will be located at adequate distances so as to ensure the protection of the retained soils.	To minimise impacts on soil structure and ecology.
Night working will be avoided where practicable. However, it may be necessary to carry out works during night time hours, such as during HDD installation operations, or in order to fill transformers with oil and undertake oil processing procedures at the onshore HVDC converter/HVAC substation. Where night working is unavoidable, light fixtures will be directed away from habitat of value to protected or otherwise notable species including badgers, birds and bats, in order to minimise likely disturbance effects of light spillage. Lighting will be kept to an absolute practicable minimum where located nearby to any active badger setts.	To minimise the disturbance impacts of light spill on protected or otherwise notable species.
Where individual mature trees are to be felled, sections of dead or decaying wood will be soft-felled (felled in sections) and, where practicable, will be relocated to suitable locations as near to the source tree as practicable, as instructed by the ECoW (i.e. within areas of similar environmental conditions, particularly with regard to shade and groundwater levels, and in locations that will not obstruct the reinstatement of previous land management practices).	To retain habitat of value to specialist invertebrate species.
An ECoW will be present on site to oversee enabling works and construction where necessary. The ECoW will be a suitably experienced professional ecologist. The ECoW will review results of protected species surveys prior to the commencement of works in different areas and will contribute to all relevant construction method statements.	To ensure works are carried out in accordance with the CoCP and comply with international and national legislation.

Measures adopted as part of Hornsea Three	Justification
Further details of measures relating to pollution prevention are set out in Environmental Statement volume 3, chapter 2: Hydrology and Flood Risk and are described in the Outline CoCP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects. Measures to be taken during HDD in relation to handling of bentonite, if required, and the requirement for plans to be produced for HDD beneath watercourses (to minimise the risk of pollution) are included in the Outline CoCP.	To minimise the potential for pollution incidents to affect habitats.
The length of individual hedgerow sections to be removed will be reduced as far as reasonably practicable according to construction methods. A works-free buffer zone will be established around mature trees, of at least equivalent to the root protection zone calculated on a tree-by-tree basis by an appropriately qualified surveyor, and the adjacent cable trench will be set in place where practicable. All sections of hedgerow removed to enable construction of the onshore cable corridor will be replanted as soon as practicable after cable installation, with regard to appropriate planting months. Replacement planting will comprise native shallow-rooting hedgerow species typical of the area. To prevent future root damage to cables, no hedgerow trees will be planted along the Hornsea Three onshore cable corridor. In addition, enhancement planting to improve connectivity and/or native species diversity will be considered on a case by case basis. Enhancement planting will include the planting of native hedgerow trees, typical of the area, at a suitable distance from the onshore cable corridor. A replanting programme to compensate for habitat lost and provide screening will be considered at the proposed HVAC booster station and onshore HVDC converter/HVAC substation sites in conjunction with mitigation measures considered as part of the landscape and visual impact assessment. Planting and management of any reinstated areas will be undertaken in accordance with the Outline EMP. Detailed landscaping proposals will be developed in an outline Landscape Management Plan. Planting will be undertaken as soon as practicable and once it can be confirmed that works will not significantly and adversely affect new planting. Where required, newly planted hedgerows will be protected by adequate fencing until the hedgerow has become established.	To minimise the likely impacts on habitats. To mitigate the effects of the temporary loss of hedgerow habitat on species such as bats.
Where considered necessary by the ECoW, or required under an EPS licence obtained from Natural England, amphibian exclusion and drift fencing will be installed along the outer edges of works areas within proximity of a GCN pond. In addition, to take account of the metapopulation dynamics of the species, the exclusion fencing will be extended to segregate any other nearby ponds which are located within 250 m of a GCN pond and which also fall within 250 m of the working corridor, provided there are no significant barriers to dispersal between these ponds and the working corridor (e.g. major roads or rivers).	To minimise the potential impacts on GCN.
Progressive and careful habitat clearance works such as the gradual strimming of above-ground vegetation such as brambles, rough grass and scrub, will be undertaken in select areas prior to construction, to deter reptiles from the working area where alternative habitat is available to them. Uprooting of vegetation of potential value to hibernating reptiles will be undertaken prior to the commencement of the hibernation period (November to March) to deter reptiles from hibernating in the area.	To minimise the potential impacts on reptiles.
A biosecurity protocol will be implemented to minimise risk of spreading invasive species. The main risks are associated with transfer of aquatic plants or animals (including vectors for disease) between watercourses or waterbodies. The majority of watercourse crossings are being undertaken using HDD, and no ponds are directly affected but where working in or near water, control measures will be implemented. These are documented in the Outline CoCP and include: • Ensuring vehicle tyres and wheel arches are cleared of mud, plants and other organic material before moving from one watercourse to another; • Leaving removed material on site; and • Cleaning boots and disinfecting (away from waterbodies to prevent potential pollutant incidents) all equipment that might come into contact with water. Appropriate measures will also be adopted when working in the vicinity of invasive terrestrial plants. Where necessary, works will be supervised by the ECoW. Known locations of invasive plant species will be marked on site and vehicle movements restricted in the vicinity of these locations. Any spoil containing or likely to contain invasive plant material to be stored separately from non-contaminated spoil, and treated as appropriate, with control measures adopted.	To minimise the potential risk of spreading disease and invasive species.

<table>
<tr><th>Measures adopted as part of Hornsea Three</th><th>Justification</th></tr>
<tr><td>In addition to measures to minimise the potential for pollution incidents, HDD is proposed for all ‘main’ and numerous ‘ordinary’ watercourses, including:
• River Glaven headwaters and tributaries;
• Blackwater Drain - Booton Common SSSI/Norfolk Valley Fens SAC;
• River Wensum SSSI/SAC;
• River Tud - Land Adjacent to River Tud CWS;
• River Bure;
• Swannington Beck;
• River Yare;
• Low Common CWS; and
• Intwood Stream.
Other locations for HDD installation include:
• Old Hall Meadow CWS; and
• Algarsthorpe Meadows
Where HDD installation is to be undertaken beneath watercourses supporting water voles or otters, consideration will be given to the location of launch pits and their relationship to watercourses. Works-free buffer zones will be established around sections of the watercourses that support water voles or otters. Buffer zones will prohibit the tracking of heavy vehicles and storage of vehicles, machinery, equipment and soils.
Drilling is expected to achieve at least 1.5 m beneath any watercourses.
Where considered necessary by the ECoW, high visibility fencing will be erected between the watercourses and adjacent riparian habitat and the works areas to prevent access by workers and heavy machinery, and to prevent storage of equipment or materials within this zone. To prevent water voles and other animals from becoming trapped in the HDD installation pits, exclusion fencing will be installed around HDD installation pits where considered necessary by the ECoW.</td><td>To minimise the potential impacts on water voles and otters.</td></tr>
<tr><td>Taking into account the mobile nature of water voles, pre-construction surveys will be undertaken to confirm the presence/absence of water voles along all watercourses of potential value to water voles.
Method statements will include pre-construction measures to deter water voles from the working corridor and an adequate buffer zone (i.e. up to 15 m where favourable habitat is present). Measures could potentially include:
• Removal of vegetation from channel and bank-side vegetative cover, up to a minimum of 1.5 m inland from the top of the bank between mid-February and early April;
• The potential capture and translocation of water voles from working areas by an appropriately qualified and experienced ecologist;
• A destructive search of water vole burrows within the working corridor under the watching brief of an appropriately qualified and experienced ecologist; and
• Measures to protect adjacent sections of the watercourse, which will not be directly impacted by trenching, such as marking out on the ground the boundary of the Hornsea Three onshore cable corridor, to control the movement of personnel and vehicles.
Works will be conducted in accordance with Natural England guidance, which states that “for summer works, vegetation removal should be carried out for a two week period prior to development. Winter works should either carry out the mitigation in September and maintain unsuitable habitat until the works commence, or in the event of an emergency, trapping and vole proof fencing may have to be employed” (Arnott, 2001). Works will also take into account best practice guidelines published in Strachan et al. (2011).</td><td>To minimise the potential impacts on water voles.</td></tr>
</table>

Measures adopted as part of Hornsea Three	Justification
Cable installation by HDD beneath watercourses of value to otters will be carried out. HDD installation pits and other excavations will be covered overnight to prevent otters entering the areas, or a method of escape (such as a plank to act as a ladder) will be provided where such excavations cannot be covered or filled on a nightly basis. Works-free buffer zones will be set up around holts (if found) and any other identified resting place, within which no tracking of heavy machinery, or storage of equipment, machinery or soils will be permitted. If night time works take place, lighting will be focussed on the works areas and away from watercourses of potential value to otters. Lighting will be kept to a minimum where it might affect holts or other identified resting places. Vehicle speeds will be limited whilst on site so as to minimise the potential for animals to be injured by vehicles. Where considered necessary by the ECoW, high visibility fencing will be erected around works-free zones. No below-ground destructive works, or tracking of heavy machinery will be undertaken a minimum distance from known otter holts. If pre-construction otter surveys report the presence of a previously unidentified otter holt or resting place within the Hornsea Three onshore cable corridor or works areas, or close enough to result in the potential disturbance of otters and if re-routing or amendments to the location of working areas are not practicable, it may be necessary to remove a holt or resting site or exclude otters from works areas using temporary otter fencing. An EPS licence for otters obtained from Natural England will be required to remove an otter holt or resting place, and may be required if works will result in disturbance and/or displacement. Advice will be sought from an experienced otter ecologist and Natural England as to the requirement for an EPS licence, prior to the commencement of works.	To minimise the potential impacts on otters.
In addition to the above-mentioned measures, including those to control vehicle speeds and minimise the likely impacts of light spillage: • No construction works will be carried out within minimum distances of an active sett entrance. Works within 30 m of a badger sett entrance may require a Natural England licence for badgers. Protection zones will be marked out on site, such as with high-visibility fencing or coloured tape; • Areas of high badger activity, if identified, will be cordoned off to ensure these are kept fully intact and with minimal interference from construction; • Excavations more than 0.5 m deep will be fenced or covered overnight where practicable, or if this is not practicable, a method of escape (e.g. a plank to act as a ladder) will be provided; and Large diameter pipes will be capped at the end of each working day to reduce the potential for badgers and other animals to enter them and become trapped.	To minimise the potential impacts on badgers.
If work within minimum distances of a sett and, therefore, sett closure or disturbance cannot be avoided, sett closures will need to be carried out outside the badger breeding season (defined as 30 November to 1st July) and in accordance with a Natural England approved method statement and, where relevant, a Natural England licence for badgers. HDD installation launch pits will be located minimum distances from active badger setts, or a Natural England licence for badgers may be required prior to the commencement of works, as considered necessary by an experienced badger ecologist. Toolbox talks on badgers will be provided by the ECoW to all construction staff on site and an emergency procedure protocol will be given to contractors in the event of encountering a badger or discovering a sett. If new setts are identified within minimum distances of the Hornsea Three onshore cable corridor, or in the areas around the HDD installation launch sites, micrositing away from the setts will be undertaken where practicable within the consented boundary of development, or a Natural England licence for badgers may be required before works continue.	To minimise the potential impacts on badgers.

Measures adopted as part of Hornsea Three	Justification
In addition to measures described above to minimise the impacts of pollutants, including airborne pollutants and light spillage, additional measures to ensure works do not result in the killing, injury or disturbance of bats are included in the Outline CoCP. These measures include: • The creation of a minimum buffer zone between cable trenches and any bat roosts identified during surveys; • If the surveys, or subsequent surveys identify the presence of additional bat tree roosts which will require removal to enable installation of the cable, this will be carried out under an EPS licence for bats obtained from Natural England; and Use of temporary 'artificial bridges' to provide a link between severed edges of hedgerows and other habitat crossed by the Hornsea Three onshore cable corridor, which have been identified as key commuting/foraging routes. The artificial bridges will be retained *in situ* throughout the construction period and until replacement planting has established and developed sufficiently to create a continuous connecting habitat. The bridges will be put into place at the end of each working day and will be retained *in situ* during the day when not working in the area.	To minimise the potential impact on bats.
All relevant mitigation measures will be implemented through the CoCP. An Outline CoCP accompanies the application for development consent.	To minimise the likely impacts on ecology and nature conservation features of interest, including biosecurity measures to prevent spread of invasive species.
Post-construction measures	
Reinstatement of damaged or cleared terrestrial habitat will be carried out as soon as practicable. Habitat reinstatement will involve the replacement of stripped soils and the planting of native hedgerows, shrubs and trees, typical of the local area and of local provenance where possible. The construction of buildings and planting of trees with deep roots will not be permitted above the onshore cable corridor to prevent potential damage to cabling. Habitat reinstatement will be undertaken in accordance with a pre-approved Landscape Management Plan. The scheme will include the retention and/or replacement of habitats of nature conservation value wherever practicable.	To minimise the period of time that habitats and species will be affected.
Bat habitat and bat roost creation, restoration or enhancement, with the aim of providing proportionate replacement for habitat lost or damaged, for example: • Erection of long-lasting woodcrete bat boxes on nearby retained mature trees to provide immediate potential roost sites as mitigation for lost tree holes of potential value to roosting bats [HOLD]; • Replacement hedgerow planting, or 'gapping up' of hedgerows along the route, including the planting of scattered native hedgerow trees where practicable; hedges with trees are greatly preferred by bats. Tree planting will provide potential long-term roosting opportunities; and Securing the long-term establishment and maintenance of replacement habitat in accordance with the landscape mitigation measures.	To minimise the potential impact on bats.
Operational phase measures	
The measures to be adopted for the avoidance of pollution of the environment during the operation of the onshore infrastructure are set out in Environmental Statement volume 3, chapter 2: Hydrology and Flood Risk.	To protect retained habitats and species.
Habitats will be managed in accordance with the Outline Environmental Management Plan (EMP) and the agreed Landscape Management Plan.	To ensure the success of habitat/landscaping proposals.
Decommissioning phase measures	
Measures to be adopted during decommissioning will be similar to those adopted during construction and will incorporate best practice guidance available at that time. These will be implemented through a decommissioning plan.	To minimise likely impacts on habitats and species of ecological or conservation interest.

4.4 Approach to in-combination assessment

4.4.1.1 The approach taken for assessment of in-combination impacts has been informed by the CEA carried out for relevant topics in the Environmental Statement for Hornsea Three. The CEA methodology is described in detail in the Environmental Statement volume 1, chapter 5: Environmental Impact Assessment Methodology) and summarised in the sections below.

4.4.1.2 In accordance with PINS Advice Note Seventeen: Cumulative Effects Assessment (PINS, 2015), other major developments (both onshore and offshore) in the area have been taken into account, including those which are:

- Under construction;
- Permitted application(s), but not yet implemented;
- Submitted application(s) not yet determined;
- Projects on the Planning Inspectorate's programme of Projects, where a scoping report has been submitted;
- Identified in the relevant development plan (and emerging development plans - with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited; and
- Identified in other plans and programmes (as appropriate) which set the framework for future development consents/approvals, where such development is reasonably likely to come forward.

4.4.1.3 Projects falling into the above categories were considered for inclusion within the CEAs presented for each topic chapter within the Environmental Statement. In order to ensure consistency between assessments this approach has been taken forward in the RIAA.

4.4.1.4 Projects/plans that were built and operational at the time of Hornsea Three data collection (field surveys etc.) have not been included within the cumulative/in-combination impact assessment. Any effects of these projects are considered to have already been captured within Hornsea Three specific surveys; hence their effects have already been accounted for within the baseline assessment. Further risk assessment may however be required if population data used to inform SPA citations is less contemporary than construction and operation of any projects and plans.

4.4.1.5 It is important to note that other projects/plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to an in-combination impact alongside Hornsea Three. For this reason, all relevant projects and plans considered cumulatively alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. Appropriate weight may therefore be given to each Tier in the decision making process when considering the potential cumulative impact associated with Hornsea Three. An explanation of each tier is provided below:

- Tier 1: Hornsea Three considered alongside other project/plans currently under construction and/or those consented but not yet implemented, and/or those submitted but not yet determined and/or those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact that is not accounted for in the baseline data;
- Tier 2: All projects/plans considered in Tier 1, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects is the most relevant source of information). Specifically, this Tier includes all projects where the developer has submitted a Scoping Report; and
- Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects is the most relevant source of information). Specifically, this Tier includes all projects where the developer has advised PINS in writing that they intend to submit an application in the future but have not submitted a Scoping Report.

4.4.1.6 It is noted that Tier 1 includes projects, plans and activities that are operational, under construction, consented but not yet implemented and submitted but not yet determined. The certainty associated with other projects, plans and activities, in terms of the scale of the development and the likely impacts, increase as they progress from submitted applications to operational projects. In particular, offshore wind farms seek consent for a maximum design scenario and the as built offshore wind farm will be selected from the range of consented scenarios.

4.4.1.7 In addition, the maximum design scenario quoted in the application (and the associated Environmental Statement) are often refined during the determination period of the application. For example, it is noted that the Applicant for Hornsea Project One has gained consent for an overall maximum number of turbines of 240, as opposed to 332 considered in the Environmental Statement. Similarly, Hornsea Project Two has gained consent for an overall maximum number of turbines of 300, as opposed to 360 considered in the Environmental Statement.

4.4.1.8 It should be noted that the in-combination assessments presented in this RIAA has been undertaken on the basis of information presented in the Environmental Statements for the other projects, plans and activities. The level of impact on European Site qualifying features would likely be reduced from those presented within this report.

4.4.1.9 A long list of relevant projects, plans and activities occurring within a large study area encompassing the entire North Sea and English Channel (offshore) and parts of Norfolk (onshore) was produced. The CEA long list collates the details of all known operational or proposed projects, plans and activities in these areas, and includes those within both the UK and adjoining international jurisdictions. In order to screen the large number of plans and projects that may be considered cumulatively/in-combination alongside Hornsea three, a stepwise process was adopted to allow for the undertaking of a methodical and transparent screening (see Environmental Statement volume 4, Annex 5.1: Cumulative Effects Screening). This process took account of the following parameters:

- Level of detail available for project/plans;
- Potential for conceptual interaction;
- Potential for physical interaction; and
- Potential for temporal interaction.

4.4.1.10 It should be noted that the potential for conceptual, physical and temporal interactions varies depending on the potential impact and feature under assessment. As such, the plans and projects requiring assessment vary depending on the feature under consideration. The specific plans and projects included are presented in detail within the in-combination assessment section for each relevant feature.

5. Assessment of Adverse Effects on Integrity: Benthic Annex I Habitat features

5.1 Introduction

5.1.1.1 The screening exercise (Stage 1 of the Habitats Regulations Assessment (HRA) process), and subsequent evaluation, identified potential for LSEs on the qualifying Annex I habitats features of The Wash and North Norfolk Coast SAC and the North Norfolk Sandbanks and Saturn Reef SAC and are detailed in Table 5.1 and shown in Figure 5.1.

5.1.1.2 This RIAA has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2016) and will be submitted as part of the Application for Development Consent.

5.1.1.3 Following the approach taken in the Hornsea Project One and Hornsea Project Two HRA, the assessment criteria and conclusions presented within the Environmental Statement volume 2, chapter 2: Benthic Ecology have been used to inform this report when considering the potential for adverse effects on site integrity in view of the Conservation Objectives of the sites being assessed. The final assessment for each effect is based upon expert judgement.

5.2 Conservation Objectives

5.2.1.1 AA requires the consideration of the impacts on the integrity of a European site, with regards to the site's structure and function and its Conservation Objectives. The Conservation Objectives of the qualifying benthic Annex I features screened in for Stage 2 assessment (Table 5.1) are provided below.

5.2.1.2 The Conservation Objectives identified within this report have been informed by the updated Natural England conservation advice for The Wash and North Norfolk Coast SAC (September 2017) and the updated JNCC conservation advice for the North Norfolk Sandbanks and Saturn Reef SAC (December 2017). The feature attribute specific targets, as informed by the supplementary advice (Natural England, 2017a & JNCC, 2017), are presented in Table 5.2. An objective of restore or maintain is set for each feature attribute.

5.2.2 The Wash and North Norfolk Coast SAC

5.2.2.1 The overarching Conservation Objectives as detailed in the Natural England updated conservation advice (Natural England, 2017a) 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 Favourable Conservation Status of its qualifying features, by maintaining or restoring:

- 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 qualifying natural habitats rely

5.2.3 North Norfolk Sandbanks and Saturn Reef SAC

5.2.3.1 The overarching Conservation Objectives for the designated features of all protected sites in UK offshore waters is to ensure they either remain in, or reach favourable condition. The ability of a designated feature to remain in, or reach favourable condition can be affected by its sensitivity to pressures associated with activities taking place within or in close proximity to a protected site.

5.2.3.2 The site specific Conservation Objectives as detailed in the updated conservation advice (JNCC, 2017) are as follows:

5.2.3.3 For the features to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Sandbanks which are slightly covered by sea water all of the time and Annex I Reefs. This contribution would be achieved by maintaining or restoring, subject to natural change:

- The extent and distribution of the qualifying habitats in the site;
- The structure and function of the qualifying habitats in the site; and
- The supporting processes on which the qualifying habitats rely.

5.3 Potential impacts

5.3.1.1 The potential effects on benthic features for each potential impact screened into the assessment (Table 5.1) have been described in the Environmental Statement Volume 2, Chapter 2: Benthic Ecology and are summarised in Table 5.3.

Table 5.1: European sites and features for which LSE cannot be discounted – benthic Annex I habitat features.

Site	Feature	Project phase	Potential Impact
The Wash and North Norfolk Coast SAC	• Sandbanks which are slightly covered by seawater all the time • Reefs – biogenic and geogenic	Construction/ Decommissioning	• Temporary habitat loss/disturbance • Temporary increases in suspended sediments/smothering • Accidental pollution
		Operation/Maintenance	• Long-term habitat loss • Colonisation of hard structures • Changes in physical processes • Temporary seabed disturbance • Accidental pollution
North Norfolk Sandbanks and Saturn Reef SAC	• Sandbanks which are slightly covered by seawater all the time • Reefs - *Sabellaria spinulosa* biogenic reef.	Construction/ Decommissioning	• Temporary habitat loss/disturbance • Temporary increases in suspended sediments/smothering • Accidental pollution
		Operation/Maintenance	• Long-term habitat loss • Colonisation of hard structures • Changes in physical processes • Temporary seabed disturbance • Accidental pollution

Table 5.2: Feature attribute target objectives

Site	Annex I Feature	Attribute	Objective
The Wash and North Norfolk Coast SAC	Sandbanks which are slightly covered by seawater all the time	Extent and distribution	Maintain
		Structure and function	Maintain
		Supporting processes	Maintain
	Reefs – biogenic and geogenic	Extent and distribution	Maintain
		Structure and function	Maintain
		Supporting processes	Maintain
North Norfolk Sandbanks and Saturn Reef SAC	Sandbanks which are slightly covered by seawater all the time	Extent and distribution	Restore

Site	Annex I Feature	Attribute	Objective
		Structure and function	Restore
		Supporting processes	Maintain
	Reefs - *Sabellaria spinulosa* biogenic reef.	Extent and distribution	Restore
		Structure and function	Restore
		Supporting processes	Restore

Table 5.3: Potential Impacts from Hornsea Three on benthic Annex I habitat features.

Project phase	Impact	Justification
Construction	Temporary habitat loss/ disturbance	There is potential for temporary, direct habitat loss and disturbance due to cable laying operations (including anchor placements), spud-can leg impacts from jack-up operations and seabed preparation works for gravity base foundations.
	Temporary increases in suspended sediments/smothering	Sediment disturbance arising from construction activities (e.g. cable and foundation installation) may result in adverse and indirect impacts on benthic communities as a result of temporary increases in suspended sediment concentrations and associated sediment deposition.
	Accidental pollution	There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.
Operation and Maintenance	Permanent/long term habitat loss	There is the potential for permanent/long term habitat loss to occur directly under all foundation structures and associated scour protection, and all subsea cables, where secondary cable protection is required.
	Colonisation of hard structures	Man-made structures placed on the seabed (foundations and scour/cable protection) are expected to be colonised by a range of marine organisms leading to localised increases in biodiversity. These structures also have the potential to act as artificial reef and serving as a refuge for fish and may facilitate the spread of non-native species.
	Changes in physical processes	The presence of foundation structures, associated scour protection and cable protection may introduce changes to the local hydrodynamic and wave regime, resulting in changes to the sediment transport pathways and associated effects on benthic ecology. Some benthic species and communities may be more vulnerable to reductions in water flow if the decrease is sufficient to reduce the availability of suspended food particles, and consequently inhibit feeding and growth. Scour and increases in flow rates can change the characteristics of the sediment potentially making the habitat less suitable for some species.
	Temporary seabed disturbance	Temporary disturbance/alteration of seabed habitats may occur during the operation and maintenance phase of Hornsea Three as a result of maintenance operations. The impacts associated with these operations are likely to be similar in nature to those associated with the construction phase although of reduced magnitude.
	Accidental pollution	There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.
Decommissioning	Effects are assumed to be similar to those predicted during the construction phase for all receptors	

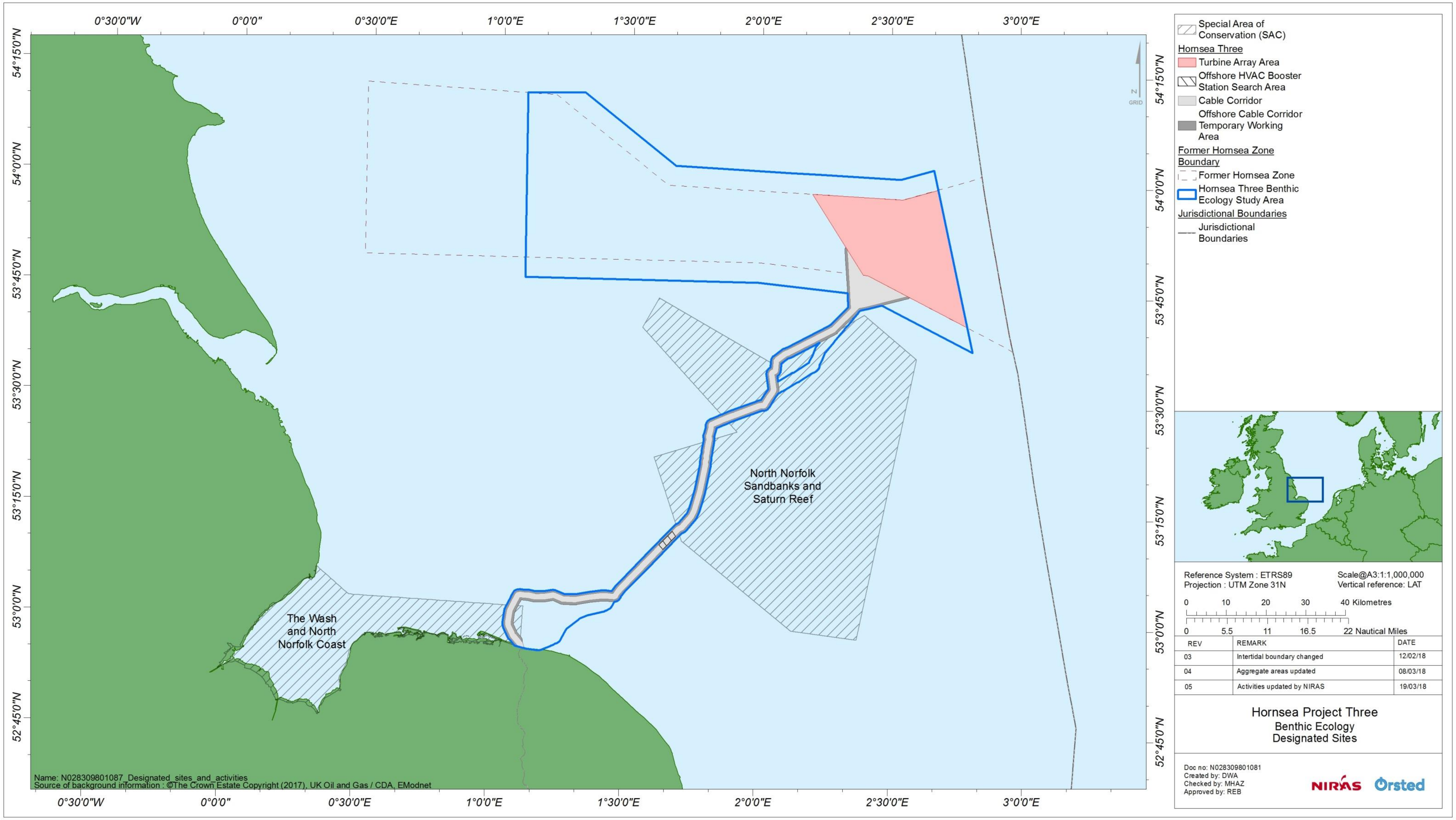


Figure 5.1: SACs in relation to Hornsea Three.

5.4 Baseline information

5.4.1 Methodology to inform baseline

5.4.1.1 Baseline information on the Annex I habitat features of the European Sites identified for further assessment within the HRA process has been gathered by a combination of desktop studies, data from benthic surveys undertaken in support of site designation and the development of appropriate management advice for the site (e.g. Jenkins *et al.*, 2015) and former Hornsea Zone historical data and Hornsea Three sites specific surveys. These sources provide information both on conditions within The Wash and North Norfolk Coast SAC and the North Norfolk Sandbanks and Saturn Reef SAC and context from the wider area.

5.4.1.2 A joint survey by JNCC and Centre for Environment, Fisheries and Aquaculture Science (Cefas) was undertaken in 2013 to develop appropriate management advice given the dynamic nature of both features, and the ephemeral nature of *Sabellaria spinulosa* structures (Jenkins *et al.*, 2015). Geophysical acquisition, Drop Down Video (DDV) and grab sampling was performed throughout the North Norfolk Sandbanks and Saturn Reef SAC with two specific objectives: to further investigate the sediments, morphology and faunal communities at the sandbanks; and to identify presence of biogenic reef features, map their extents and characterise the associated faunal communities.

5.4.2 Evidence Plan

5.4.2.1 The Evidence Plan process has been set out in the Hornsea Three Offshore Wind Farm – Evidence Plan, the purpose of which is to agree the information Hornsea Three needs to supply to PINS, as part of a DCO application for Hornsea Three. The Evidence Plan seeks to ensure compliance with the HRA.

5.4.2.2 As part of the Evidence Plan process, the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology Expert Working Group (EWG) was established with representatives from the key regulatory bodies and their advisors and statutory nature conservation bodies, including the MMO, Cefas, JNCC and Natural England. Representatives from The Wildlife Trust (TWT), who were not part of the EWG at the start, joined the EWG from February 2017. Between June 2016 and publication of the ES, a series of EWG meetings were held that included discussion of key issues regarding benthic ecology elements of Hornsea Three, including characterisation of the baseline environment, the impacts to be considered within the impact assessment and implications associated with the offshore cable corridor reroutes. A summary of the key issues raised during consultation specific to benthic ecology and matters raised during EWG meetings are presented in the Environmental Statement volume 2, chapter 2: Benthic Ecology and full meeting minutes are presented within the Evidence Plan (Consultation Report, Annex 1 Evidence Plan).

5.4.2.3 The baseline characterisation of the Hornsea Three offshore cable corridor has drawn upon several Hornsea Three site-specific surveys completed in 2016 and 2017 together with desktop information from third-party surveys, including surveys targeting areas within and near designated sites (Table 5.4). The site-specific surveys of the Hornsea Three offshore cable corridor comprised geophysical data acquisition along the corridor, benthic sampling and DDV surveys, to establish a robust and up-to-date characterisation of the baseline environment in the Hornsea Three offshore cable corridor. The site-specific Hornsea Three offshore cable corridor surveys were discussed and agreed through the Marine Processes, Benthic Ecology and Fish and Shellfish EWG.

5.4.3 Desktop study

5.4.3.1 Information on benthic ecology was collected through a detailed desktop review of existing studies and datasets. The key data sources are summarised in Table 5.4, although this should not be considered an exhaustive list of references. Further detail is presented within Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report.

5.4.4 Site specific surveys

5.4.4.1 Survey data collected from the Hornsea Three array area and Hornsea Three offshore cable corridor in 2016 and 2017, together with historic benthic ecology survey data from the former Hornsea Zone, have been used to inform the baseline characterisation, as agreed with the Marine Processes, Benthic Ecology and Fish and Shellfish EWG (see Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report).

5.4.4.2 A summary of the surveys undertaken to date is outlined in below (Table 5.5) and benthic sampling locations are shown in Figure 5.2.

Table 5.4: Summary of key desktop reports.

Title	Source	Year	Author
Humber Regional Environmental Characterisation (REC)	Marine Aggregate Levy Sustainability Fund (MALSF)	2011	Tappin *et al.*
Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region	Humber Aggregate Dredging Association (HADA)	2012	Environmental Resources Management (ERM)
European Marine Observation Data Network (EMODnet) Seabed Habitats Project	EUSeaMap 2016: www.emodnet-seabedhabitats.eu/	2016	EUSeaMap 2016
UK Benthos Database	Oil and Gas UK: http://oilandgasuk.co.uk/product/ukbenthos/	2015	Oil and Gas UK
North Sea Benthos Project (NSBP) 2000	North Sea Benthos Project 2000: www.vliz.be/vmdcdata/nsbp/	2001	International Council of the Exploration of the Sea (ICES)
Technical reports for the Offshore Oil and Gas Strategic Environmental Assessment (SEA) Areas 2 and 3	UK Government, Department of Energy and Climate Change (DECC).	2001	Department of Trade and Industry (DTI)
North Norfolk Sandbanks and Saturn Reef SCI management investigation report.	Joint Nature Conservation Committee (JNCC), Cefas	2015	Jenkins *et al.*
Sheringham Shoal Offshore Wind Farm Environmental Statement and pre-construction survey data.	Scira Offshore Energy	2006 2009	Scira Offshore Energy; Brown and May
Dudgeon Offshore Wind Farm Environmental Statement	Dudgeon Offshore Wind Limited	2009	Royal Haskoning Warwick Energy

Table 5.5: Summary of benthic ecology surveys.

Title	Extent of survey	Overview of survey	Survey contractor	Year	Reference to further information
Historic survey data within the Hornsea Three benthic ecology study area					
Zone characterisation (ZoC) benthic sampling survey	Former Hornsea Zone	122 combined DDV and Hamon grab sampling stations, plus 40 epibenthic beam trawl stations	EMU Ltd	2010	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Project One benthic sampling survey	Former Hornsea Zone	161 combined DDV and Hamon grab sampling stations, of which 40 stations were sampled for sediment chemistry, plus 41 epibenthic beam trawl stations	EMU Ltd	2010 to 2011	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Project Two benthic infill survey	Former Hornsea Zone	51 combined DDV and Hamon grab sampling stations, of which 8 stations were sampled for sediment chemistry, plus 21 epibenthic beam trawl stations	EMU Ltd	2012	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Site specific surveys within Hornsea Three					
Hornsea Three array area geophysical and benthic sampling survey	Hornsea Three array area	Geophysical survey consisting of dual frequency side scan sonar and multibeam echosounder and 20 ground truthing Hamon grab samples for PSA and infaunal analysis	EGS International Ltd (EGSi)	2016	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three offshore cable corridor geophysical and benthic sampling survey	Hornsea Three offshore cable corridor	Geophysical survey consisting of dual frequency side scan sonar and multibeam echosounder and 19 combined DDV and Hamon grab sampling stations plus one DDV sampling station	Bibby HydroMap Limited and Benthic Solutions	2016	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three intertidal survey	Hornsea Three intertidal area (mean low water spring (MLWS) to MHWS)	Phase I walkover habitat survey habitat with 0.1 m^2 dig-over sampling	RPS Energy	2016	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report

Title	Extent of survey	Overview of survey	Survey contractor	Year	Reference to further information
Hornsea Three benthic sampling survey - beyond 60nm	Cable fan section of the Hornsea Three offshore cable corridor and three sampling stations in Markham's Hole within the Hornsea Three array area	6 stations, 3 of which were also sampled for sediment chemistry, and 10 stations for DDV only	Gardline	2017	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three benthic sampling survey - within 60 nm	Hornsea Three offshore cable corridor out to 60 nm	14 combined Hamon grab sampling and DDV stations, 15 stations for DDV only, 5 stations for sediment chemistry only, 5 beam trawls.	Ocean Ecology	2017	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report
Inshore geophysical and DDV survey	Hornsea Three offshore cable corridor coinciding with the Wash and North Norfolk Coast SAC and Cromer Shoal Chalk Beds MCZ	49 DDV transects targeting potential outcropping rock; geophysical data (side scan sonar and bathymetry).	Fugro GB Marine	2017	Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report

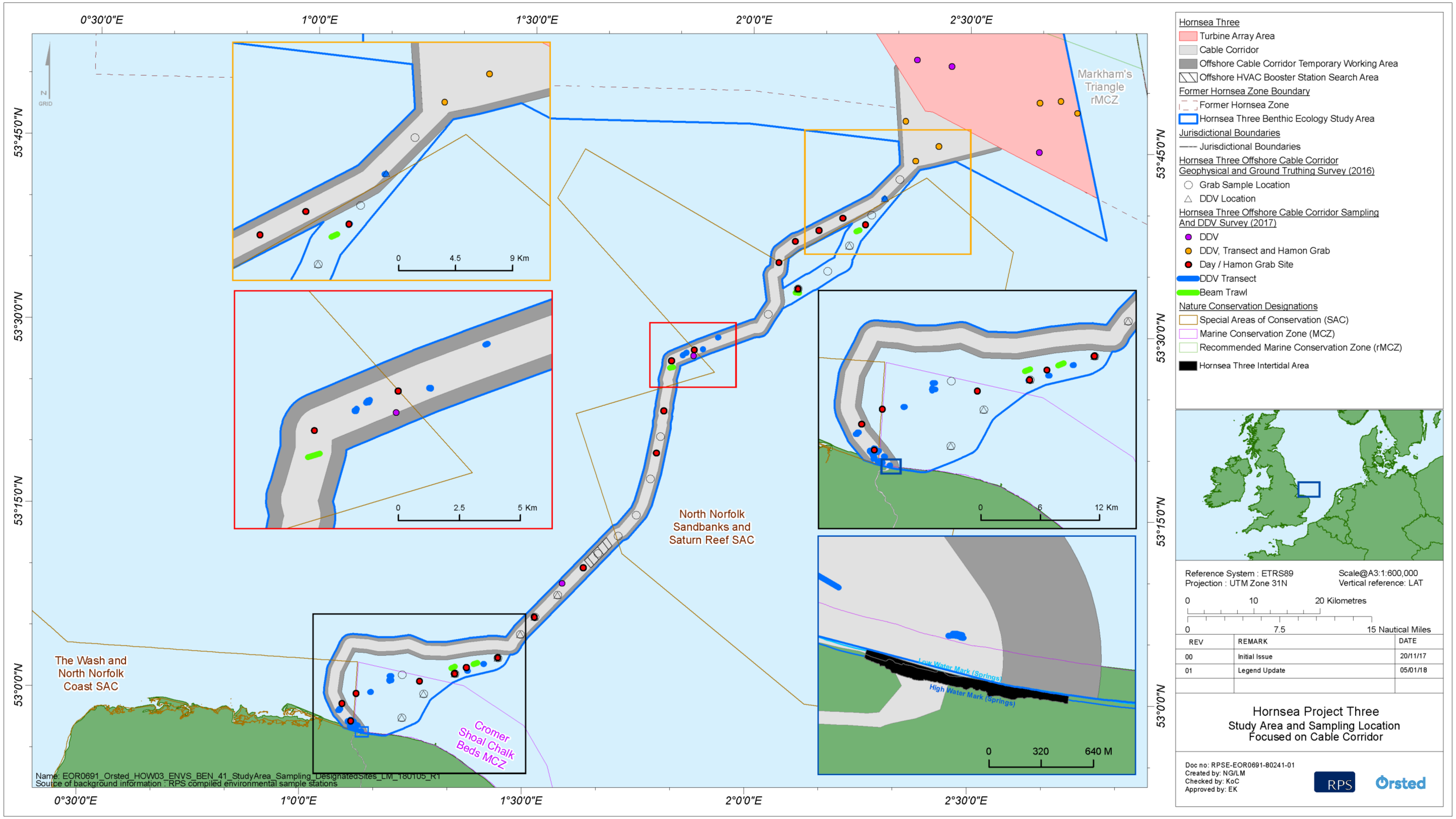


Figure 5.2: Hornsea Three offshore cable corridor with Hornsea Three (2016 and 2017) benthic ecology sampling locations (benthic grabs, DDV and trawls).

5.4.5 The Wash and North Norfolk Coast SAC

5.4.5.1 The nearshore section of the Hornsea Three offshore cable corridor passes through the easternmost section of the Wash and North Norfolk Coast SAC (Figure 5.2). This site is designated for the following benthic subtidal features which are relevant to Hornsea Three project:

- Sandbanks which are slightly covered by sea water all the time (Subtidal sandbanks);
- Reefs (circalittoral rock, subtidal biogenic reefs (mussel beds and *Sabellaria* spp. reefs) and subtidal stony reef).

5.4.5.2 All other subtidal features and intertidal features of this site (i.e. mudflats and sandflats not covered by seawater at low tide; large shallow inlets and bays; *Salicornia* and other annuals colonising mud and sand; Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*); and Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) are not considered relevant to Hornsea Three as they are either located in The Wash or in the intertidal zone west of Hornsea Three and outside the agreed zones of influence (ZoI).

5.4.5.3 Data from MAGIC indicate that the eastern boundary of the SAC is characterised by subtidal mixed sediments. Subtidal mixed sediment communities recorded within the SAC include *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment (SS.SMx.CMx.FluHyd) and the SS.SBR.PoR.SspiMx biotope (APEM, 2013; Natural England, 2017a), consistent with the findings of previous surveys in the area (e.g. those for the Sheringham Shoal offshore cable corridor). Subtidal sand was also mapped by MAGIC near to the Hornsea Three offshore cable corridor. Along the North Norfolk coast part of the SAC, subtidal sand biotopes were primarily characterised by the *Nephtys cirrosa* and *Bathyporeia spp*. in infralittoral sand (NcirBat) and Infralittoral mobile clean sand with sparse fauna (SS.SSa.IFaSa.IMoSa) biotopes (APEM, 2013; Natural England, 2017a).

5.4.5.4 Subtidal mud was present (according to MAGIC) in a limited number of discrete areas with communities recorded in the SAC including *Nephtys hombergii* and *Macoma balthica* in infralittoral sandy mud (SS.SMu.ISaMu.NhomMac), although data presented by APEM (2013) did not indicate that these sediments were present in the western part of the SAC (i.e. where the Hornsea Three offshore cable corridor coincides with the SAC). Subtidal coarse sediment communities were reported to be relatively rare along the North Norfolk coast, with most records within The Wash (Natural England, 2017), although MAGIC showed a band of shallow subtidal coarse sediments along the interface with the intertidal. The coarse sediment communities along the North Norfolk coast were reported to be characterised by the biotopes Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand (SS.SCS.ICS.SLan) and *Protodorvillea kefersteini* and other polychaetes in impoverished mixed gravelly sand (SS.SCS.CCS.Pkef) (APEM, 2013; Natural England, 2017).

5.4.5.5 Reef habitats and communities (i.e. both stony reef and biogenic reef) have been recorded throughout the SAC, although these were primarily recorded within The Wash, with fewer occurrences in the east of the SAC (Meadows and Frojan, 2012; McIlwaine *et al.,* 2014; Natural England, 2017a). Stony reef is present to the north of the Well and along the western flanks of the Well in the deeper reaches of The Wash. These habitats include mixed and coarse sediment as well as patches of stony reef and as such it was challenging to calculate the extent of stony reef within the SAC accurately. Communities associated with these stony reef habitats were characterised by biotopes including *Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata (CR.HCR.XFa.FluHocu) (Meadows and Frojan, 2012; McIlwaine *et al.,* 2014; Natural England, 2017a).

5.4.5.6 *Sabellaria spinulosa* reef has been detected throughout much of the subtidal area of The Wash; however, given its ephemeral nature its presence is highly variable in both space and time. The most consistent records of *Sabellaria spinulosa* reef include along the edges of the Well, Roaring Middle, Lynn Deeps and Lynn Knock (Jessop *et al.,* 2010; Jessop *et al.,* 2012; Bussell and Saunders, 2010; Jessop and Maxwell, 2011, as presented in Natural England, 2017a). However, the mixed sediment communities in the vicinity of the Hornsea Three offshore cable corridor are characterised by the SS.SBR.PoR.SspiMx biotope, which is supported by the findings of the Sheringham Shoal baseline characterisation and monitoring surveys in the same area, although in this area (i.e. south of the Sheringham Shoal sandbank) no biogenic reef was recorded.

5.4.5.7 The sediments and biotopes identified within the SAC are shown in figures

5.4.5.8 Figure 5.3 and Figure 5.4 respectively.

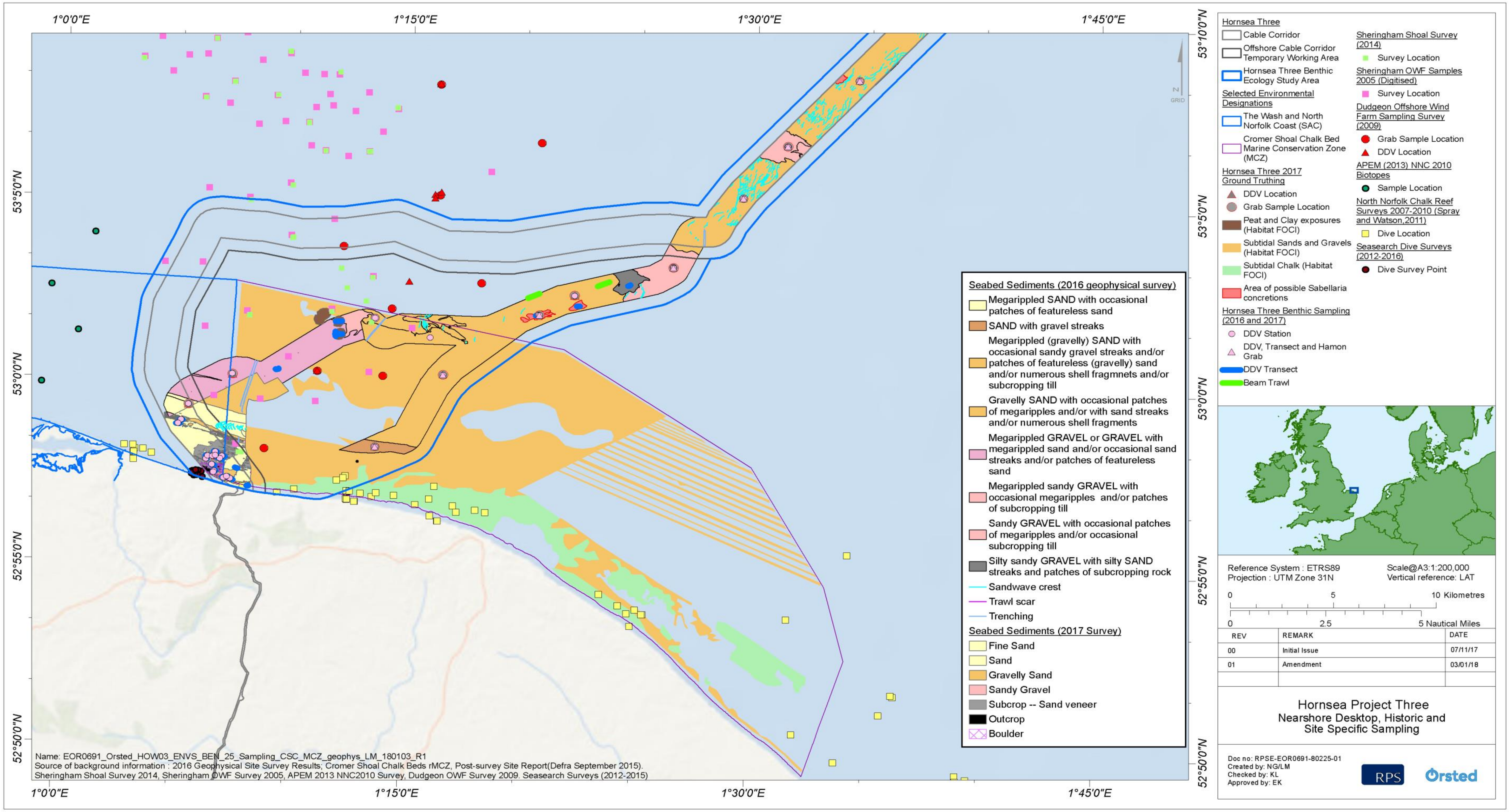


Figure 5.3: Nearshore section of Hornsea Three offshore cable corridor, with Hornsea Three site specific geophysical data and benthic sampling locations (2016 and 2017) and historic datasets (i.e. Sheringham Shoal (2006 and 2014), Dudgeon (2009), Cromer Shoal Chalk Bed MCZ (Defra, 2015) and The Wash and North Norfolk Coast SAC (APEM, 2013; Natural England, 2017a)

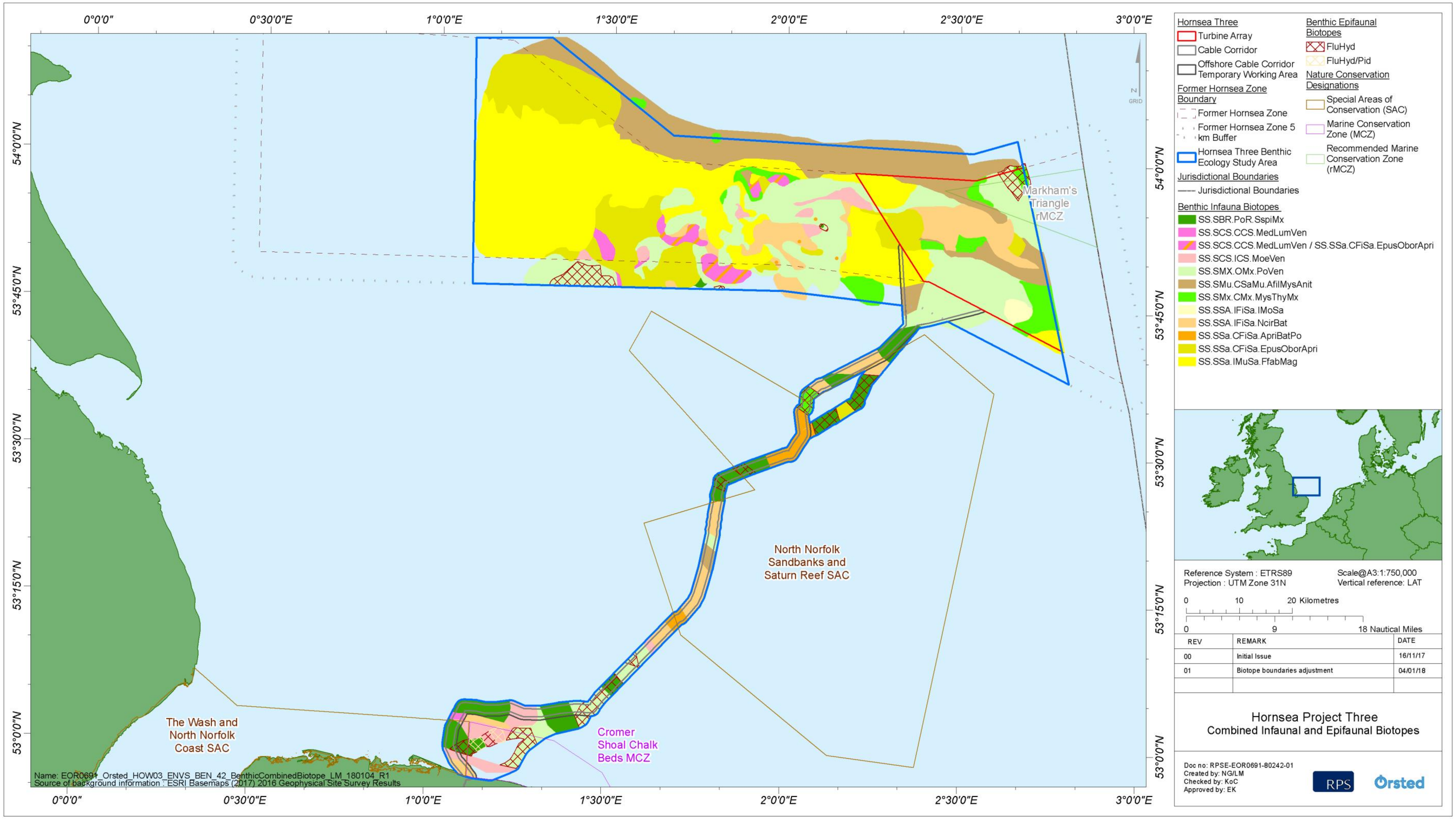


Figure 5.4: **Combined infaunal and epifaunal biotope map of the Hornsea Three benthic ecology study area.**

5.4.6 Norfolk Sandbanks and Saturn Reef SAC

5.4.6.1 The North Norfolk Sandbanks and Saturn Reef SAC coincides with part of the central and seaward end of the Hornsea Three offshore cable corridor (Figure 5.1) and is designated for the following Annex I habitats:

- Sandbanks which are slightly covered by sea water all the time; and
- Reefs (including the Saturn *Sabellaria spinulosa* biogenic reef).

5.4.6.2 The North Norfolk Sandbanks and Saturn Reef SAC, which extends from approximately 40 km off the north Norfolk coast out to approximately 110 km offshore, encompasses the most extensive area of offshore linear ridge sandbanks in the UK (JNCC, 2010a), and also coincides with approximately two thirds of the Hornsea Three offshore cable corridor. The sandy sediments support sparse infaunal communities of polychaete worms, isopods, crabs and starfish which are typical of the biotope 'infralittoral mobile clean sand with sparse fauna' (Connor *et al*., 2004).

5.4.6.3 A joint survey by JNCC and Cefas was undertaken in 2013 to develop appropriate management advice given the dynamic nature of both features, and the ephemeral nature of *Sabellaria spinulosa* structures (Jenkins *et al.,* 2015). Geophysical acquisition, DDV and grab sampling was performed throughout the North Norfolk Sandbanks and Saturn Reef SAC with two specific objectives: to further investigate the sediments, morphology and faunal communities at the sandbanks; and to identify presence of biogenic reef features, map their extents and characterise the associated faunal communities.

Sandbanks which are slightly covered by seawater all the time

5.4.6.4 Overall six sandbanks were investigated, three of the most inner sandbanks (Leman Bank, Inner Bank and Wells bank), adjacent to the central section of the Hornsea Three offshore cable corridor, and three of the most offshore sandbanks of the Indefatigables, adjacent to the furthest offshore section of the Hornsea Three offshore cable corridor (Figure 5.5). Despite the range in distance between the southern and northern extents of the site, the area within the North Norfolk Sandbanks and Saturn Reef SAC largely comprises sandy sediments and this sediment type is generally consistent throughout the site according to SeaZone HydroSpatial data, EUSeaMap data and the REC data.

5.4.6.5 Sampling on the sandbanks during the Cefas/JNCC survey revealed very subtle differences in the particle size across the profiles of the sandbanks. Sediment comprised medium sand throughout the profiles of both nearshore and offshore sandbank features with no statistically significant differences in mean particle size between the trough, flank or crest of the offshore sandbanks. Only minor, statistically significant differences were observed in particle size between the troughs, flanks and crest in the nearshore sandbanks (Jenkins *et al.,* 2015). However, the troughs of both nearshore and offshore sandbanks were determined to comprise slightly higher coarse and mud content compared to the flanks and crests.

5.4.6.6 An analysis of the infaunal communities revealed that numbers of taxa and abundances increased with depth throughout the SAC site, and that species richness was highest in the troughs of the sandbanks and lowest on the crests. ANOSIM tests showed significant differences between the infaunal communities of the nearshore (adjacent to central section of the Hornsea Three offshore cable corridor) and offshore sandbanks (adjacent to the furthest offshore section of the Hornsea Three offshore cable corridor), however the difference was small (Global R: 0.2), indicating a substantial overlap in faunal composition between nearshore and offshore communities (Jenkins *et al.,* 2015). The apparently small differences in faunal community supports the broad patterns concluded from HADA MAREA and REC datasets for this region, in that biotopes did not vary considerably with distance from the shore. Statistically significant, but very small (Global R: 0.14), differences were identified in community assemblage between the crest, flank and trough features of the offshore sandbanks, while no such differences were observed for the inner sandbanks (Jenkins *et al.,* 2015). Characterising species within the areas sampled included the polychaetes *Ophelia borealis, Polycirrus, Lagis koreni, Scoloplos armiger* and *Nephtys cirrosa,* and the amphipod *Bathyporeia guilliamsoniana*.

Reefs

5.4.6.7 The presence of the Saturn Sabellaria spinulosa biogenic reef within the North Norfolk Sandbanks and Saturn Reef SAC was first recorded in 2002 (JNCC, 2008), within 100 m of the edge of the Hornsea Three offshore cable corridor. In 2003 the Saturn reef covered an area of approximately 750 m by 500 m and was located between Swarte and Broken Banks on the edge of a small sandbank (BMT Cordah, 2003). Subsequent surveys failed to locate the same reef structure at this location, with bottom trawling or the natural ephemeral nature of the Sabellaria spinulosa reef proposed as possible factors associated with its apparent disappearance (JNCC, 2010a).

5.4.6.8 However, in 2013, Cefas undertook another survey of the SAC which identified a potential westward migration of the Saturn Reef (originally recorded in the 2003 survey) or, more likely, the loss of the original reef feature and the development of new reef structures, consistent with the ephemeral nature of *Sabellaria spinulosa* biogenic structures. The 2013 data show the latest structures to overlap with the Hornsea Three offshore cable corridor (See Figure 5.5).

5.4.6.9 For the investigation into biogenic reef features within the North Norfolk Sandbanks and Saturn Reef SAC, six survey areas were identified where reefs had previously been recorded. These areas were investigated with high resolution multibeam echosounder, side scan sonar, DDV and Hamon grab sampling. Two of the survey areas were located within the SAC site, which coincided with the central section of the Hornsea Three offshore cable corridor. Seven patches of *Sabellaria spinulosa*, with generally 'low reef' quality (according to Gubbay, 2007), were identified and delineated, with areas ranging between 0.004 km^2 and 1.5 km^2 (Jenkins *et al.,* 2015); these areas are shown as tan coloured polygons in Figure 5.5, together with the previously known position and extent of the Saturn Reef (indicated by the dark green area). These data have revealed a potential westward migration of the Saturn reef (identified in the 2003) or, more likely, the loss of the original reef feature and the development of a new reef structure, demonstrating the ephemeral nature of *Sabellaria spinulosa* aggregations.

5.4.6.10 It is widely acknowledged that *S. spinulosa* reef is a naturally ephemeral habitat and is vulnerable to both natural disturbance (e.g. storms) and anthropogenic activities such as bottom trawling. Therefore, the Hornsea Three site specific survey data showing that the reef recorded by JNCC/Cefas in 2013 is no longer present, is not unusual for this ephemeral reef habitat. It is possible, however, that *S. spinulosa* reefs may form within the Hornsea Three offshore cable corridor, in the intervening time between Hornsea Three characterisation surveys and Hornsea Three pre-construction Annex I reef surveys. Should Annex I *S. spinulosa* reef be identified in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be discussed with statutory consultees and the primary objective will be to avoid direct impacts to these Annex I reefs, where (see Table 4.5). In order to address uncertainties with regard to the potential for direct impacts on potential future for *S. spinulosa* reefs (i.e. where avoidance is not possible in areas where reef may develop), a precautionary assessment of the effects to potential future Annex I reef has been undertaken, further details of which can be found in Environmental Statement volume 2, chapter 2: Benthich Ecology. The aims of this assessment are threefold:

- To identify areas where Annex I reef is most likely to occur in the part of the North Norfolk Sandbanks and Saturn Reef SAC coinciding with the Hornsea Three offshore cable corridor, based on historic records of Annex I reef in this area, and to determine the risk of reef being present during the pre-construction survey (noting that *S. spinulosa* reef is ephemeral and was not recorded during the Hornsea Three site specific surveys);
- To determine the likelihood of an impact occurring to any potential future reef (should this develop) as a result of export cable installation considering a range of cable installation scenarios (i.e. between zero and six cables installed through potential future reef features; and
- Based on these precautionary scenarios described in the bullet points above, to describe and assess the effect of cable installation on potential future Annex I *S. spinulosa* reef(s).

5.4.6.11 To determine the risk of Annex I reef being present in the part of the SAC coinciding with the Hornsea Three offshore cable corridor prior to construction, the principles of the core reef approach, which were used to map the distribution of *S. spinulosa* reef in the 2010 and 2014 Wash *S. spinulosa* synthesis (Roberts et al., 2016), have been applied. The core reef approach provides a means of predicting areas where reef is most likely to occur (i.e. where conditions are favourable to consistent presence of *S. spinulosa reef*, either continuously or frequently recurring). Further information on this approach can be found in Environmental Statement volume 2, chapter 2: Benthich Ecology. The Reef Index values calculated for the area of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC are mapped in Figure 5.6.

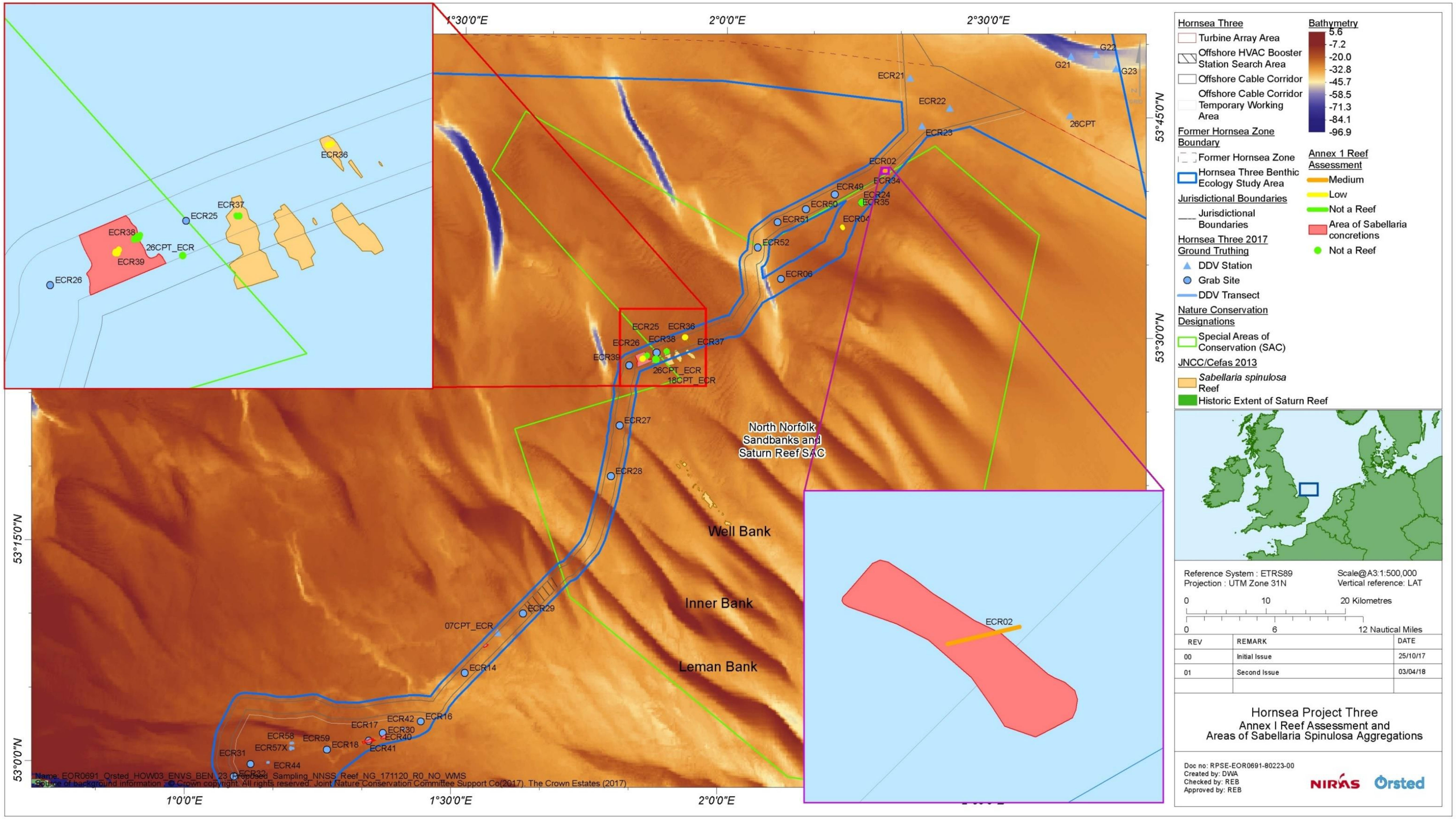


Figure 5.5: The Hornsea Three offshore cable corridor and Sabellaria spinulosa reefs recorded during a survey undertaken by Cefas in 2013 and Sabellaria spinulosa concretions recorded in the Hornsea Three site specific surveys, together with associated reefiness assessments.

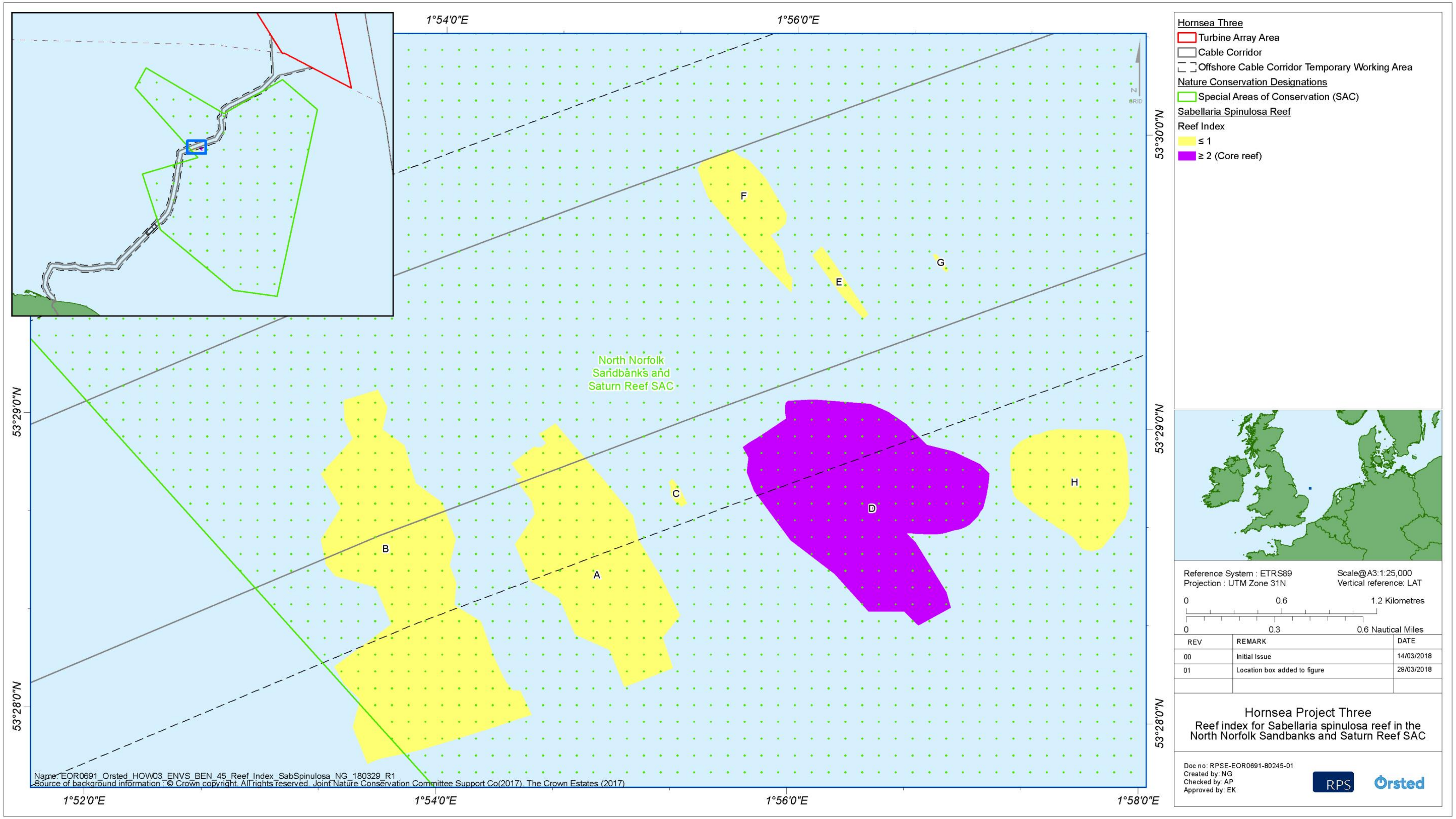


Figure 5.6: Reef Index for *S. spinulosa* reef in the area of the North Norfolk Sandbanks and Saturn Reef SAC coinciding with the Hornsea Three offshore cable corridor using data collected between 2003 and 2017.

5.5 The Wash and North Norfolk Coast SAC Assessment of Adverse Effects on Integrity – Alone

5.5.1 Potential impacts - construction/decommissioning

5.5.1.1 A description of the potential effects on offshore qualifying Annex I habitats caused by each identified potential impact is given below.

Temporary habitat loss/disturbance

5.5.1.2 Of the total predicted temporary habitat loss/disturbance described in Table 4.1, a maximum of 2,356,714 m^2 of this is predicted to affect subtidal habitats within The Wash and North Norfolk Coast SAC (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements) (Table 5.6), which represents 0.22% of the total area of The Wash and North Norfolk Coast SAC. For the purposes of this assessment, a precautionary approach has been adopted which assumes that all the subtidal sediment within The Wash and North Norfolk Coast SAC has the potential to be the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'. Sandwave clearance material from sandwaves cleared within The Wash and North Norfolk Coast SAC will be deposited within the boundary of site at a location that considers the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see Environmental Statement volume 2, chapter 1: Marine Processes, section 1.11.5).

Table 5.6: Temporary habitat loss of Annex I habitat within The Wash and North Norfolk Coast SAC.

Project Element	Temporary habitat loss/disturbance (m^2)	Assumptions
Pre-construction sandwave clearance	999,000	Clearance of sandwaves along up to 66.6 km of cable, with up to six cables, each of up to 11.1 km length within The Wash and North Norfolk Coast SAC. Sandwave clearance will affect a corridor of up to 30 m width of seabed (i.e. an additional 15 m width of disturbance on the 15 m associated with cable burial) (66,600 m x 15 m = 999,000 m^2).
Pre-construction sandwave clearance disposal activities	265,474	Up to 265,474 m^2 from placement of coarse, dredged material to a uniform thickness of 0.5 m because of sandwave clearance on the offshore cable corridor, assuming a volume of up to 132,737 m^3 of sandwave clearance material.
Cable burial	999,000	Burial of up to a total of 66.6 km cable length, with up to six cables, each of 11.1 km length within The Wash and North Norfolk Coast SAC. Cable installation will affect a corridor of up to 15 m width of seabed (66,600 m x 15 m = 999,000 m^2).
Anchor placements	93,240	Up to seven anchors (each with a footprint of 100 m^2) repositioned every 500 m of the 66.6 km cable length within The Wash and North Norfolk Coast SAC, with up to six export cables (11,100 m x 100 m^2 x 7 x 6 / 500 m = 93,240 m^2).
Total temporary habitat loss/disturbance within The Wash and North Norfolk Coast SAC	2,356,714 m^2	

5.5.1.3 The Wash and North Norfolk Coast SAC is also designated for Annex I reefs, however, historically, no reefs have been recorded in the area of the Hornsea Three benthic ecology study area that coincides with The Wash and North Norfolk Coast SAC and neither were they recorded during the recent site specific surveys in this area. Should Annex I *Sabellaria spinulosa* reef be identified in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place to avoid direct impacts to these reefs where possible. As such, figures are not presented for the temporary loss/disturbance of Annex I reef habitat as direct impacts to this habitat will be avoided.

5.5.1.4 The maximum design scenario for temporary habitat loss/disturbance assumes that pre-construction sandwave clearance would occur along the entire extent of export cables within The Wash and North Norfolk Coast SAC. This is, however, a precautionary assumption and there may be discrete areas in which sandwave clearance will not be required but boulder clearance may be required. Although this will not contribute to any additional habitat loss, the process will effectively redistribute boulders and cobbles within discrete areas and potentially concentrate these in the areas either side of the 25 m boulder clearance corridor.

5.5.1.5 A post-construction survey at Humber Gateway offshore wind farm examined the effects of export cable and inter array cable installation on Annex I stony reefs, resulting in corridors of comparatively flat seabed crossing through elevated stony reef features (Precision Marine Survey Ltd (PMSL), 2016). Cable installation in these areas resulted in a reduction in the structural complexity of Annex I stony reefs, particularly on the export cable route, including elevation from the surrounding seabed and coverage of boulders and cobbles within the cable corridors. Outside the areas of Annex I stony reef, the seabed comprised relatively flat seabed with mixed, coarse sediments and post construction monitoring showed considerably less variation in the surface of the seabed or evidence of cable installation (PMSL, 2016). This was supported by DDV sampling in these areas, which showed the presence of pebbles and muddy sandy gravel (i.e. reflecting the pre-construction baseline) in areas where cables had been installed approximately one year previously.

5.5.1.6 It should be noted that the seabed in the nearshore environment off the Holderness coast is different in character to nearshore environment off the North Norfolk coast (i.e. within the Hornsea Three benthic ecology study area). The seabed off the Holderness coast comprises very coarse substrate with a high occurrence of pebbles, cobbles and boulders (including Annex I stony reefs), while the sediments off the North Norfolk coast are largely sandy and mixed in nature, with only patchy distributions of cobbles and boulders, none of which qualified as Annex I stony reef (see section 4.1.4 of Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report 1 for full details). The evidence from post construction monitoring at Humber Gateway offshore wind farm indicates that mixed sediments of sand and gravels would be expected to recover following cable installation, with clear evidence of recovery of sediments to pre-construction baseline conditions approximately one year post-construction (PMSL, 2016).

5.5.1.7 Therefore, where boulder clearance occurs (i.e. corridors of up to 25 m width within the Hornsea Three offshore cable corridor), this will not represent a significant shift in the baseline situation as any boulders which are present within these areas will be displaced a short distance from their original locations. Since no sediment/substrate is being removed, this will not act as a barrier for the recovery of any epifaunal communities impacted during the process.

5.5.1.8 The mobility of material in the nearshore area is such that under storm conditions, the combined action of currents and waves is expected to remobilise sediments with grain size of up to 100 mm (cobbles) in water depths of up to 8 m and up to 15 mm (pebble gravel) in deeper nearshore areas (up to 14 m). This demonstrates that, over time, there will be a redistribution of the material displaced during boulder clearance and, whilst it is not possible to determine where the sediment will be redistributed to, it is reasonable to assume that some of the material will be moved back in to the areas which were cleared, thus partially restoring the topography of the area.

5.5.1.9 The subtidal biotopes that were recorded within the Hornsea Three offshore cable corridor within The Wash and North Norfolk Coast SAC, as shown in Figure 5.4, were NcirBat at the landward end, merging into MoeVen and then SspiMx extending offshore (although it should be noted that potential Annex I reef was not detected in association with the SspiMx biotope).

5.5.1.10 Analysis of historic and site specific data does not indicate the presense of Annex I Sandbanks which are slightly covered by sea water all the time or Annex I Reefs coinciding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occurring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurrence of this biotope in this location is not indicative of this feature in this instance.

5.5.1.11 The sensitivity of the SspiMx biotope to temporary disturbance is considered to be of medium sensitivity to extraction (e.g. from sandwave clearance) as well as to abrasion and disturbance (e.g. from cable burial and anchor placements) (Environmental Statement volume 2, chapter 2: Benthic Ecology). Although this biotope is considered to have none to low intolerance to these pressures, recoverability is likely to be medium (Tillin and Marshall, 2015). For the deposition of material from sandwave clearance activities, this biotope is considered to have no resistance to this impact but recovery will be rapid. Following cable installation, the sediments within the impacted areas are predicted to recover to a condition which will not affect the potential for *S. spinulosa* reef to develop in the future.

5.5.1.12 The impact of temporary loss/disturbance within The Wash and North Norfolk Coast SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, of medium term (i.e. construction phase of up to eight years over two phases (a gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction) although export cable installation will only comprise a small proportion of this (up to three years), intermittent in nature and reversible.

Conclusion

5.5.1.13 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1 in relation to temporary habitat loss/disturbance. There is no indication that temporary habitat loss/disturbance would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the extent and distribution, supporting processes, structure and function of Annex I sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication that temporary habitat loss/disturbance would lead to an adverse change to the biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

Temporary increases in suspended sediments/smothering

5.5.1.14 Impacts to Annex I habitat features of The Wash and North Norfolk Coast SAC from increased SSC and smothering are predicted to arise from export cable installation and associated sandwave clearance only. The impact on these habitats will be of limited spatial extent, medium term duration (export cables installation activity will be intermittent and non-continuous, over a period of up to four years), intermittent and reversible.

5.5.1.15 Analysis of historic and site specific data does not indicate the presence of Annex I Sandbanks which are slightly covered by sea water all the time or Annex I Reefs coinciding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occurring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurrence of this biotope in this location is not indicative of this feature in this instance.

5.5.1.16 The subtidal biotopes that were recorded within the Hornsea Three offshore cable corridor coinciding with The Wash and North Norfolk Coast SAC, as shown in Figure 5.4, are NcirBat at the landward end, merging into MoeVen and then SspiMx extending offshore. The NcirBat biotope is not sensitive to smothering and has a low sensitivity to SSC (Tillin, 2016a). Similarly, the sensitivity of the MoeVen biotope communities to increased SSC is low (Tillin, 2016b). The increase in SSC would inhibit light penetration to the water column and limit availability of phytoplankton as a food source to filter-feeding organisms, however such an impact would be limited in extent and phytoplankton would be expected to be brought into the area from outside the area of impact.

5.5.1.17 *Sabellaria spinulosa* is tolerant of increased SSC (Tillin and Marshall, 2015) and a limited amount of sediment deposition by fine sediment is likely to be well within the tolerance of *Sabellaria spinulosa.* As such, Annex I *Sabellaria spinulosa* reefs are not considered to be sensitive to increases in SSC.

<u>Conclusion</u>

5.5.1.18 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1, in relation to temporary increases in suspended sediments/smothering. There is no indication that temporary increases in suspended sediments/smothering would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the extent and distribution, supporting processes, structure and function of sandbanks which are slightly covered by seawater all the time or reef habitats. Nor is there any indication that these effects would lead to an adverse change to the diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

Accidental pollution

5.5.1.19 There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.

5.5.1.20 The total additional number of construction-related vessel round trips to port expected because of construction activities over the construction period is up to 10,774. The highest intensity of construction activities and subsequently the majority of vessel activity will be occuring within the project array area, remote from the SAC. The magnitude of the impact of this increase will be dependent on the quantities of potential pollutants carried by construction vessels and intertidal vehicles/machinery. The size of most of these potential sources of pollution in the intertidal will be relatively small, which immediately reduces the potential magnitude of any spill and although a spill in the intertidal at low water would directly affect benthic habitats, it would be easy to contain. In addition, although many of the large construction vessels may contain large quantities of diesel oil, any accidental spill from vessels, vehicles, machinery or from construction activities would be subject to immediate dilution and rapid dispersal in the high energy environment found within the subtidal parts of Hornsea Three. Additionally, the majority of vessel trips will be made to and from the project area from suitable ports distant from The Wash and North Norfolk Coast SAC further reducing the likelihood of an adverse impact and subsequently and adverse effect on site integrity.

5.5.1.21 Given the designed-in mitigation (Table 4.5) the likelihood of accidental release is considered to be extremely low. The measures included in the Project Environmental Management and Monitoring Plan (PEMMP) alongside the implementation of best working practices will significantly reduce the likelihood of an accidental pollution incident occurring. Measures adopted as part of Hornsea Three to reduce the potential for impacts on shipping and navigation (see Environmental Statement volume 2, chapter 7: Shipping and Navigation), such as vessels complying with the International Regulations for Preventing Collisions at Sea (COLREGs), will further reduce the likelihood of an accident between vessels resulting in an accidental spill during the construction period). This will also apply to activities associated with cable installation occurring within the SAC.

There is a risk to subtidal benthic receptors from water based drilling mud (i.e. bentonite) which is used as a lubricant during the HDD) process, should HDD be used at the Hornsea Three intertidal area to install the export cable. A limited volume of drilling mud will be discharged at the point where the bore punches out of the seabed in the subtidal zone. However, the volume of fluids released will be small and quickly dispersed in the high-energy conditions of the marine environment. As such, impacts to surrounding subtidal bentic features will be minimal.

<u>Conclusion</u>

5.5.1.22 Provided published guidelines, best working practices and the mitigation measures outlined in Table 4.5 are adhered to, the likelihood of an accidental spill is extremely low and, in the event of a spill, the volumes of potential contaminants released would be small and rapidly dispersed to concentrations below which deleterious effects would be expected. Consequently, significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1, in relation to accidental pollution.

5.5.1.23 There is no indication that accidental pollution events would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the extent and distribution, supporting processes, structure and function of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

5.5.2 Potential impacts - operation and maintenance

Permanent/long term habitat loss

5.5.2.1 It is predicted that there will be some loss of habitat directly under export cables where cable protection is required.

5.5.2.2 Of the total permanent/long term habitat loss predicted for Hornsea Three (Table 4.1) up to 46,200 m^2 of this is predicted to occur within The Wash and North Norfolk Coast SAC (i.e. from cable protection where burial is not possible). This represents 0.004% of the total area of the site. This results from the potential requirement for cable protection for up to 10% of the 66 km of export cables within The Wash and North Norfolk Coast SAC (six cables of up to 11 km in length), and up to 7 m width of cable protection per cable (11,000 m x 6 x 0.1 x 7 m = 46,200 m^2). Cable protection requirements along the Hornsea Three offshore cable corridor will be detailed in the Cable Specification and Installation Plan, which will be produced prior to construction and agreed with the MMO.

5.5.2.3 Analysis of historic and site specific data does not indicate the presense of Annex I Sandbanks which are slightly covered by sea water all the time coinciding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occurring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurrence of this biotope in this location is not indicative of this feature in this instance.

5.5.2.4 Annex I reef is also a qualifying feature of The Wash and North Norfolk Coast SAC. Historically, no reefs have been recorded in the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC and neither were they recorded during the site specific surveys in this area. Therefore, no direct effects from permanent/long term habitat loss are predicted. Should Annex I *S. spinulosa* reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place where possible to avoid direct impacts to these reefs from cable protection.

5.5.2.5 The impact of permanent/long term habitat loss within The Wash and North Norfolk Coast SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed (0.004% of the site) within the eastern periphery of The Wash and North Norfolk Coast SAC. Hornsea Three will employ sensitive cable protection within the areas of designated sites that coincide with Hornsea Three which will consider the local seabed conditions, including sediment/substrate type. These cable protection measures will not include concrete mattresses and will take into account the local baseline environment (see Table 4.5). Hornsea Three will discuss and agree the precise nature of the cable protection measures for The Wash and North Norfolk Coast SAC with the MMO through sign of on the Cable Specification and Installation Plan prior to construction. This may include the use of rock protection which takes into account the typical grain sizes (e.g. coarse gravel and cobbles) known to occur naturally within the SAC. Where appropriately sized rock protection can be used, such measures may allow some recovery of communities in areas where cable protection is placed and reducing the extent of permanent/long term habitat loss in The Wash and North Norfolk Coast SAC. The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime of Hornsea Three.

5.5.2.6 It is acknowledged that the presence of the cable protection material on the seabed has the potential to act as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. The MarESA for the SspiMx biotope does note, however, that *S. spinulosa* has been recorded colonising bedrock and artificial structures and an increase in the availability of hard substratum may, therefore, may be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different (Tillin and Marshall, 2015). Furthermore, as the overall proportion of The Wash and North Norfolk Coast SAC predicted to be affected is very small, 0.004% of the total area of the site, there will remain sufficient similar habitat available for the potential colonisation by *Sabellaria spinulosa* and establishment of reefs in the future. The same is also true for available habitat for the creation of Annex I 'Sandbanks which are slightly covered by seawater all the time'. Therefore, it is not considered that the presence of cable protection within The Wash and North Norfolk Coast SAC will preclude the establishment of Annex I reefs, or Annex I 'Sandbanks which are slightly covered by seawater all the time' in these areas in the future.

5.5.2.7 With respect to the Conservation Objectives for the SAC, there is no indication that permanent/long term habitat loss will lead to a reduction in environmental quality, nor will it inhibit natural environmental processes (see also 5.5.2.23 onwards). It is predicted that there will be a slight loss of habitat extent, however, this represents 0.004% of the Annex I habitat features within the SAC. The magnitude of the impact on the Annex I habitat qualifying features of the site is considered to be negligible and would result in an insignificant change in the baseline condition.

5.5.2.8 The impact will result in localised changes in the physical structure of the habitat and the loss of associated species that rely upon those habitats. As the extent of these effects is very limited, however, within the context of the SAC, it is not predicted that these changes will lead to a significant or widespread reduction in diversity, community structure or the typical species associated with the Annex I habitats present.

Conclusion

5.5.2.9 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1, in relation to permanent/long term habitat loss.There is no indication that localised permanent/long term habitat loss would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats especially when considering the dynamic and transient nature of these habitats. Additionally, there is no indication that localised permanent/long term habitat loss would lead to any significant adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

Colonisation of hard structures and Invasive Non-Native Species (INNS)

5.5.2.10 The introduction of up to 57,135 m^2 of surface area of new hard substrate is predicted to occur because of the protection of up to 10% of the 66 km of export cables (six cables of up to 11 km in length) within The Wash and North Norfolk Coast SAC. This is predicted to affect up to 0.005% of the potential Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC. This impact is not predicted to affect any Annex I reef features of The Wash and North Norfolk Coast SAC as, as discussed, no reefs were identified within the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC during the site specific surveys and should Annex I reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place where possible to avoid direct impacts to these reefs from cable protection.

5.5.2.11 With regards to the colonisation of hard structures by existing communities, the type of substrate used in cable protection may influence the magnitude of change to the existing communities. Hard substrate from boulders have the potential to support a higher biodiversity and species abundance than soft bottom substrates. In comparison, gravels may result in a lower biodiversity increase and abundance of organisms due to the more unstable environment which they provide (Langhamer 2012 in Pidduck *et al.,* 2017).

5.5.2.12 The risks of introduction and spread of INNS during both the construction, and operation and maintenance phases have been considered and this assessment is considered to be equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Biological pressures':

- Introduction or spread of non-indigenous species.

5.5.2.13 The benchmark for the relevant MarESA pressure (of the same name) which has been used to inform this impact assessment is the direct or indirect introduction of one or more INNS.

5.5.2.14 The impact from construction vessels has been considered together with the impact during the operation and maintenance phase because the majority of this impact will arise as a result of the introduction of hard substrate associated with foundations and cable/scour protection with a smaller potential contribution from vessel movements.

5.5.2.15 The introduction of hard substrate into a predominantly soft sediment area can facilitate the spread of non-native species which may predate on, and compete with, existing native species (Inger *et al.*, 2009). Recent studies have demonstrated the potential for offshore renewable energy devices to act as ecological 'stepping stones', facilitating the spread of pelagic larval particles that would otherwise have been lost offshore and allowing the transgression of natural biogeographical boundaries (Adams *et al.*, 2014). However, there is little evidence from post construction monitoring undertaken to date to suggest that the hard structures associated with offshore wind farms provide any new or unique opportunities for non-indigenous species which could facilitate their introduction (Linley *et al.*, 2007).

5.5.2.16 There will be up to 10,774 round trips to port during the construction phase and up to 2,885 round trips to port by operational and maintenance vessels, which will contribute to the risk of introduction or spread of INNS in ballast water. The highest intensity of construction activities and subsequently the majority of vessel activity will be occuring within the project array area remote from the SAC. Designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will, however, ensure that the risk of potential introduction and spread of INNS will be minimised.

5.5.2.17 Habitats along the Hornsea Three offshore cable corridor, including within North Norfolk Sandbanks and Saturn Reef SAC, are likely to be subjected to a lower risk of INNS introduction than the array area as only export cables will be present and the cable will be buried for the most part.

5.5.2.18 Additionally, the risk of introduction of INNS by ballast water will be considerably lower along the cable corridor, including within The Wash and North Norfolk Coast SAC, than at the Hornsea Three array, as only a limited number of round trips by operational and maintenance vessels will be required for the Hornsea Three offshore cable corridor and over a greater geographic area.

5.5.2.19 Any impact on the qualifying features in The Wash and North Norfolk Coast SAC is predicted to be of local spatial extent (though the introduction of structures may serve as 'stepping stones' and extend the impact on a regional, national, or international scale (however it is not possible to predict such a spread), long term duration (35 years - lifetime of Hornsea Three), continuous and irreversible. However, the sandbank and reefs habitats of the site are considered to have low vulnerability to this potential impact.

5.5.2.20 Although the introduction of some INNS could lead to changes in the diversity and structure of faunal communities, the risk of this significantly affecting the Annex I habitats of The Wash and North Norfolk Coast SAC due to the colonisation of hard structures introduced into the SAC due to Hornsea Three is considered to be very slight.

Conclusion

5.5.2.21 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1 in relation to the colonisation of hard structures and potential introduction of INNS.

5.5.2.22 There is no indication that the colonisation of hard structures or introduction of INNS would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication of a significant risk of an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

Changes in physical processes

5.5.2.23 Cable burial and potential cable protection also has the potential to affect the morphology, hydrodynamics and sediment transport (littoral drift) at the nearshore area, which could lead to potential impacts on coastal habitats including Annex I habitats within The Wash and North Norfolk Coast SAC.

5.5.2.24 Following burial, the only way in which the cables could influence hydrodynamics and beach morphology during operation would be if they became exposed as a consequence of natural changes. Detailed understanding of the likely temporal variability in beach topography throughout the lifetime of the project is therefore critical for the appropriate siting of cables as well as determination of appropriate burial depths. This has been considered through analysis of recent and historic beach monitoring data (including LiDAR) which enables the range of historical natural variability to be determined, including patterns and trends of erosion and accretion. Findings are presented in Environmental Statement volume 5, annex 1.1: Marine Processes Technical Annex, section 6.

5.5.2.25 In theory, the use of cable protection measures in shallow nearshore areas could also influence beach morphology through modification of the wave regime and blockage of sediment transport. If and where cable protection measures are installed in shallow subtidal locations near to the nearshore area, they could also potentially influence the local nearshore wave regime and resulting patterns of sediment transport in the nearshore and intertidal areas. However, it is more realistically assumed that any cable protection measures used in such areas would be installed with a sufficiently low profile and width relative to the surrounding bed so as to present minimal barrier to the passage of waves and so would cause minimal change to patterns of longshore sediment transport.

5.5.2.26 The natural processes controlling the variability in beach morphology will continue to act in the same way following installation of the cables and irrespective of any temporary local disturbance caused.

5.5.2.27 The actual extent of any change will be dependent upon the particular seastate (combination of individual wave heights and periods and directions) relative to the dimensions and orientation of the cable protection measures, and the distance and orientation to the adjacent beach or coastline. As such, the area of change may not even extend as far as the adjacent coastline. No change on wave period is anticipated. As a result, no measurable changes to patterns of longshore sediment transport are expected.

5.5.2.28 Cable protection could also present an obstacle to sediment transport, trapping sediment locally and thereby impacting down-drift locations through a reduction in sediment supply. Cable protection would be placed onto the seabed surface above the cable and therefore could present an obstacle to sediment transport, trapping sediment locally and thereby impacting down-drift locations through a reduction in sediment supply. The approach taken to inform this assessment in described in 5.6.2.29 - 5.6.2.36.

5.5.2.29 Any potential impacts associated with cable exposure are predicted to be of local spatial extent, short-term duration, continuous and high reversibility. Any impacts associated with the presence of cable protection measures are predicted to be of local spatial extent, long-term duration, continuous and high reversibility. It is predicted that any impacts will affect the receptor indirectlyHowever, the shoreline is typically a dynamic environment which is often subject to a large amount of natural change under baseline conditions. Accordingly, it is assessed to have some capacity to recover from disturbance.

5.5.2.30 Therefore, no effects are predicted on habitats within The Wash and North Norfolk Coast SAC as a result of changes to the wave regime. Impacts associated with cable protection will only exert a highly localised influence on the tidal regime such that the magnitude is considered to be negligible.

Conclusion

5.5.2.31 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1 in relation to changes in physical processes during operation/maintenance activities.

5.5.2.32 There is no indication that changes in physical processes arising from the operation of Hornsea Three would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication that changes in physical processes would lead to an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

Temporary seabed disturbance

5.5.2.33 Temporary disturbance/alteration of seabed habitats within The Wash and North Norfolk Coast SAC may occur during the operation and maintenance phase of Hornsea Three as a result of maintenance operations.

5.5.2.34 Of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance (Table 4.1) up to 198,838 m^2 of this is predicted to affect The Wash and North Norfolk Coast SAC over the 35 year design life of Hornsea Three as a result of export cable remedial burial and repair activities. This equates to approximately 0.02% of the total habitat within The Wash and North Norfolk Coast SAC. It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 7% of the total export cable length coincides with The Wash and North Norfolk Coast SAC, 7% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. Temporary disturbance to Annex I reef features within this site will be avoided where possible to minimise any direct impacts. The impact is predicted to be of local spatial extent, short term duration (i.e. individual cable maintenance operations would occur over the period of days to weeks, over up to a maximum of three months for cable repairs), intermittent and reversible.

<u>Conclusion</u>

5.5.2.35 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1 in relation to temporary seabed disturbance during maintenance activities.

5.5.2.36 There is no indication that temporary seabed disturbance during maintenance activities would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication that temporary seabed disturbance during maintenance activities would lead to an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

Accidental pollution

5.5.2.37 There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.

5.5.2.38 The magnitude of the impact is entirely dependent on the nature of the pollution incident but the Strategic Environmental Assessment (SEA) carried out by Department of Energy and Climate Change (DECC, 2011) recognised that, "renewable energy developments have a generally limited potential for accidental loss of containment of hydrocarbons and chemicals, due to the relatively small inventories contained on the installations (principally hydraulic, gearbox and other lubricating oils, depending on the type of installation)". Such sources are present only in the array area and do not represent a hazard to any Natura 2000 Site.

5.5.2.39 A potential for accidental spills will also occur as a result of the 2,885 round trips to port by maintenance and operational vessels and up to 4,671 round trips by helicopter per year over the 35 year design life of Hornsea Three. However, most of these vessels will be crew/supply vessels and helicopters servicing the array area, will be typically small and will therefore be carrying only limited amounts of potential contaminants and remote from the SAC. Although larger operational and maintenance vessels may contain larger quantities of potential pollutants (e.g. jack up vessels) such as diesel oil, movements of these vessels will be far fewer in comparison to smaller vessels. Additionally, the majority of vessel trips will be made to and from the project area from suitable ports distant from The Wash and North Norfolk Coast SAC further reducing the likelihood of an adverse impact and subsequently and adverse effect on site integrity.

5.5.2.40 Throughout operation there will be the requirement to store fuel offshore for the purposes of refuelling CTVs and/or helicopters, this storage will be on up to three of the offshore accommodation platform barges. An impact on benthic ecology features of the SAC would only be realised if an incident occurs where the fuel is accidentally released. Given the distance between the array area and the SAC, it is highly unlikely that any accidental spill within the array area would have an impact on the designated features. The historical frequency of pollution events in the southern North Sea benthic ecology study area is low considering the density of existing marine traffic in the area. Given the designed-in mitigation (Table 4.5: Designed-in measures adopted as part of Hornsea Three – offshore benthic Annex I habitats.Table 4.5) which is proposed (i.e. a PEMMP); it is considered that the likelihood of accidental release is extremely low. Furthermore, the likelihood of a collision between vessels resulting in an accidental spill during the operation and maintenance period will be further reduced by the HSE MS which will be developed and implemented by Ørsted which incorporates the elements of the ASMS, as required by MGN 543 (see Environmental Statement, volume 2, chapter 7: Shipping and Navigation).

5.5.2.41 The risk of an accidental pollution event upon subtidal benthic receptors and subsequently the qualifying Annex I habitat features of The Wash and North Norfolk Coast SAC, is predicted to be of local to regional spatial extent, short term duration, intermittent and reversible. It is predicted that the impact would affect SAC features directly and/or indirectly, but that the likelihood of an accidental pollution incident occurring is very small.

Conclusion

5.5.2.42 Provided published guidelines, best working practices and the mitigation measures outlined in Table 4.5 are adhered to, the likelihood of an accidental spill is extremely low and, in the event of a spill, the volumes of potential contaminants released would be small and rapidly dispersed to concentrations below which deleterious effects would be expected. Consequently, significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of The Wash and North Norfolk Coast SAC identified in Table 5.1, in relation to accidental pollution during operation and maintenance.

5.5.2.43 There is no indication that accidental pollution would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Nor is there any indication that these effects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of The Wash and North Norfolk Coast SAC from this potential impact is concluded.

5.6 North Norfolk Sandbanks and Saturn Reef SAC Assessment of Adverse Effects on Integrity – Alone

5.6.1 Potential impacts - construction/decommissioning

5.6.1.1 A description of the potential effects on offshore qualifying Annex I habitats caused by each identified potential impact is given below.

Temporary habitat loss/disturbance

5.6.1.2 Temporary loss/disturbance of subtidal habitat within Hornsea Three offshore cable corridor, and subsequently the sections of the North Norfolk Sandbanks and Saturn Reef SAC which overlap with this, is predicted to occur as a result of installation of export cables.

5.6.1.3 It was agreed with the JNCC (EWG) that when assessing this impact on the North Norfolk Sandbanks and Saturn Reef SAC it should be assumed that the sites Annex I habitat qualifying features are present across the entire area of the site.

Sandbanks

5.6.1.4 Of the total temporary habitat loss/disturbance described in Table 4.1, up to a maximum of 9,305,800 m^2 of this is predicted to occur within Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from pre-construction sandwave clearance (and sandwave material deposition) boulder clearance and cable installation including anchor placements) (Table 5.7). This represents 0.26% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC/Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the SAC (i.e. the entire SAC is assigned to the Annex I sandbank habitat, as it is designated and viewed as one integrated sandbank system; JNCC, 2010a).

Table 5.7: Temporary habitat loss of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (assuming all sediment assigned to this Annex I habitat).

Project Element	Temporary habitat loss/disturbance (m^2) of Sandbanks which are slightly covered by seawater all the time	Assumptions
Pre-construction sandwave clearance	2,880,000 m^2	Clearance of sandwaves along up to 192 km of cable, with up to six cables, each of up to 32 km length within the North Norfolk Sandbanks and Saturn Reef SAC. Sandwave clearance will affect a corridor of up to 30 m width of seabed (i.e. an additional 15 m width of disturbance on the 15 m associated with cable burial) (192,000 m x 15 m = 2,880,000 m^2).

Project Element	Temporary habitat loss/disturbance	Assumptions
Pre-construction sandwave clearance disposal activities	1,239,400 m²	Up to 1,239,400 m² from placement of coarse, dredged material to a uniform thickness of 0.5 m because of sandwave clearance on the offshore cable corridor, assuming a volume of up to 619,700 m³ of sandwave clearance material.
Pre-construction boulder clearance	900,000 m²	Clearance of boulders along up to 90 km of cable, with up to six cables, each of up to 15 km length within the North Norfolk Sandbanks and Saturn Reef SAC. Boulder clearance will affect a corridor of up to 25 m width of seabed (i.e. an additional 10 m width of disturbance on the 15 m associated with cable burial) (90,000 m x 10 m = 900,000 m²).
Cable burial	4,230,000 m²	Burial of up to a total of 282 km cable length, with up to six cables, each of 47 km length within the North Norfolk Sandbanks and Saturn Reef SAC. Cable installation will affect a corridor of up to 15 m width of seabed (282,000 m x 15 m = 4,230,000 m²).
Anchor placements	56,400 m²	Up to one anchor (footprint of 100 m² each) repositioned every 500 m of the 282 km cable length within the North Norfolk Sandbanks and Saturn Reef SAC, with up to six export cables (282,000 m x 100 m² x 6 / 500 m = 56,400 m²).
Total temporary habitat loss/disturbance within the North Norfolk Sandbanks and Saturn Reef SAC	9,305,800 m²	-

5.6.1.5 Sandwave clearance material from sandwaves cleared within the North Norfolk Sandbanks and Saturn Reef SAC will be deposited within the same sandwave system generally expected to be within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC. The precise disposal location selected within the Hornsea Three disposal sites (see Environmental Statement volume 4, annex 3.2: Dredging and Disposal: Site Characterisation) will consider the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see 2.11.1.13 to 2.11.1.14 and section 1.11 in Environmental Statement volume 2, chapter 1: Marine Processes). It is reasonable to assume a similarity of sediment particle size with depth through the sandwave on the basis of sediment transport processes, therefore, in most cases the deposited material is likely to be similar in nature to that present in the area in which it is deposited. Where sands are deposited into areas of different seabed type however (e.g. areas of slightly coarser seabed in some sandwave troughs), the seabed may become locally relatively finer in texture until the body of sand has been winnowed away or reincorporated into a bedform migrating over that location. In all cases, the deposited sediments would be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions.

5.6.1.6 The potential for seabed recovery following sandwave clearance along the Race Bank export cable route, as well as for wider changes to sediment transport patterns, for the Inner Dowsing, Race Bank and North Ridge SAC has previously been considered as a detailed desktop study to inform the Race Bank HRA (DONG Energy, 2016b).

5.6.1.7 Both the Race Bank offshore wind farm export cable and Hornsea Three offshore cable corridor pass through similarly dynamic areas of seabed characterised by highly mobile sediment and migrating bedform features. The conclusions reached in DONG Energy (2016b), which are supported by the monitoring described in DONG Energy (2017), are considered to be also applicable for areas of sandwave clearance by dredging within the Hornsea Three offshore cable corridor. These conclusions are summarised in Environmental Statement volume 2, chapter 1: marine processes 1.11.5.

5.6.1.8 In summary, it is suggested that no sediment volume will be removed from the sandbank systems overall. The displaced material will be of the same or similar sediment type (mineralogy and grain size distribution) as the surrounding seabed and, following re-settlement, will be immediately available again for transport at the naturally occurring rate and direction, controlled entirely by natural processes. As such, the sediment will have immediately re-joined the natural sedimentary environment within the local area and so by definition is not 'lost from the system' due to the dredging/spoil disposal process. The same sediment might be subsequently transported outside of the sandbank system over time (in the order of tens to hundreds of years) by natural sediment transport processes, but this is no different from the baseline situation. At worst, sediment might be redistributed within the sandbank system so as to cause a temporary local imbalance of sediment budget and a new equilibrium will be established in time (in the order of months to years) through natural sediment transport processes.

5.6.1.9 Should a marine disposal licence for a new disposal site (see Environmental Statement volume 4, annex 3.2: Dredging and Disposal: Site Characterisation) not be granted within the vicinity of the dredging areas, material may have to be transported some distance by vessel and therefore be potentially 'lost' from the system. Although local disposal would be preferable to this scenario, it is still considered unlikely that it would adversely affect the form and function of the designated features within the North Norfolk Sandbanks and Saturn Reef SAC. This is because the area impacted is small relative to the overall size of the SAC.

Reefs

5.6.1.10 Although the Hornsea Three offshore cable corridor coincides with the JNCC delineated boundary of *Sabellaria spinulosa* reef in the North Norfolk Sandbanks and Saturn Reef SAC, no Annex I reefs were identified during the site specific surveys of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC.

5.6.1.11 As outlined above in 5.4.6.11 and discussed further in Environmental Statement volume 2, chapter 2: Benthic Ecology, the risk of Annex I reef being present in the part of the SAC coinciding with the Hornsea Three offshore cable corridor prior to construction, has been determined following the principles of the core reef approach. The core reef approach provides a means of predicting areas where reef is most likely to occur (i.e. where conditions are favourable to consistent presence of S. spinulosa reef, either continuously or frequently recurring).

5.6.1.12 Although, no areas of core reef (i.e. areas identified as having a Reef Index ≥2) were identified within the Hornsea Three offshore cable corridor, a precautionary approach has been adopted to the assessment whereby the assessment has been undertaken for all areas of potential future Annex I reef not qualifying as core reef within the Hornsea Three offshore cable corridor. The assessment is therefore considered to be highly precautionary. Environmental Statement volume 2, chapter 2: Benthic Ecology, Table 2.21 presents the likelihood of each scenario (i.e. 0 to 6 cables installed through each reef feature). The maximum design scenario has the potential to result in either the truncation of an area of potential future Annex I *S. spinulosa* reef (i.e. by a cable(s) being installed at the periphery of an area of reef) or in the bisection of an area of potential future Annex I *S. spinulosa* reef resulting in potential increased instability of the resulting smaller areas of reef and the possible loss of integrity of these features. It should be noted however that, even if the primary mitigation of avoiding reefs where possible fails and export cables need to be installed through an area of reef(s), the cables would still be microsited through areas of lower quality reef, avoiding areas of medium or high quality reef (see Table 4.5).

5.6.1.13 The impact of temporary loss/disturbance from cable installation Annex I reef features of the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, of medium term duration (i.e. construction phase of up to eight years for the Hornsea Three offshore cable corridor, although export cable installation will only comprise up to three years), intermittent and reversible. It is predicted that the impact may affect receptors directly with the potential for partial loss of/damage to key characteristics, features or elements of the Annex I reefs. However, the most likely magnitude of any impact is considered to be negligible or, at worst, minor for the following reasons:

- The low risk of Annex I reefs occurring within the Hornsea Three offshore cable corridor;
- The primary mitigation for Annex I reefs is to avoid these entirely, where possible (see Table 4.5);
- The high likelihood that this primary mitigation measure will be effective as the Hornsea Three offshore cable corridor is of sufficient width to allow cables to be microsited around *S. spinulosa* reefs in all but the most unlikely potential future Annex I reef scenarios; and
- In the event that cable installation within Annex I reefs is unavoidable (e.g. due to practical or engineering constraints), the cables would be microsited through areas of lower quality reef, avoiding areas of medium or high quality reef and/or cable installation would be restricted to the periphery of reef features to ensure continuous reef features are not bisected (see Table 4.5).

5.6.1.14 Larvae of *S. spinulosa* are strongly stimulated to metamorphose by the secretions of their own species, and therefore settle preferentially on sediment used previously by other S. spinulosa individuals (Wilson, 1970). Therefore, they may build on the ruins of earlier reefs (e.g. in areas where reefs have been disturbed or removed), and may promote recovery of a reef which had previously deteriorated, providing prevailing environmental conditions are still appropriate (Hendrick and Foster-Smith, 2006). This was demonstrated by monitoring at the Lynn and Inner Dowsing offshore wind farm where *S. spinulosa* was recorded within the jack-up footprints from wind turbine foundation installation (EGS, 2012). Similarly, this is reflected in the historic data for the North Norfolk Sandbanks and Saturn Reef SAC which has demonstrated the presence of *S. spinulosa* reef in the same broad area of the SAC over subsequent years (see Area D ‘core reef’ in Figure 5.6). *S. spinulosa* is commonly found in disturbed environments and has a typically high rate of reproduction (Holt et al., 1998). *S. spinulosa* is often one of the first species to settle on newly exposed surfaces (OSPAR Commission, 2010). The presence of any remaining *S. spinulosa* adults will also assist in larval settlement of this species (Jackson and Hiscock, 2008). Therefore, even if localised areas of Annex I reef were disturbed during cable installation this would not preclude the recovery of reef in such areas should all other environmental conditions remain favourable for the presence of reef (i.e. assuming successful cable burial and recovery of seabed sediments to the pre-construction baseline).

<u>Conclusion</u>

5.6.1.15 The North Norfolk Sandbank is an open shelf ridge sandbank, formed by strong tidal currents, and the Conservation Objectives and Advice on Operations document for the site states that, in response to physical loss, the sandbank could be replenished and recovery relatively rapidly between removal activities and sensitivity to removal and physical damage is assessed as moderate (JNCC, 2012).

5.6.1.16 There is no indication that there will be any significant changes to the physical structure or any shift in the biological communities of species that are associated with the qualifying Annex I habitats of the North Norfolk Sandbanks and Saturn Reef SAC, particularly when proposed mitigation is taken into consideration. Any effects of habitat loss/disturbance within the construction phase will cease following completion of construction activities. Recovery is likely to be high and typically within five years or less, as a result of passive import of larvae and active migration of juveniles and adults from adjacent non-affected areas.

5.6.1.17 With respect to the Conservation Objectives for the SAC, therefore, there is no indication that temporary habitat loss/disturbance will lead to a reduction in environmental quality, nor will it inhibit natural environmental processes. Although it is predicted that there will be a slight loss of habitat extent, this represents 0.26% of the Annex I habitat features within the SAC. When considering that this is inevitably an overestimate as not all this area is Annex I qualifying feature habitat in real terms, the magnitude of the impact on the Annex I habitat qualifying features of the site is considered to be negligible and would result in an insignificant change in the baseline condition.

5.6.1.18 Consequently, significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1 in relation to temporary habitat loss/disturbance. There is no indication that temporary habitat loss/disturbance would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication that temporary habitat loss/disturbance would lead to an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Temporary increases in suspended sediments/smothering

5.6.1.19 Sediment disturbance arising from construction activities may result in adverse impacts on benthic communities as a result of temporary increases in suspended sediment concentrations and associated sediment deposition.

5.6.1.20 As detailed in Table 4.1, increases in suspended sediment concentrations (SSC) and associated sediment deposition are predicted to occur during the construction phase as a result of export cable installation (including seabed preparation and sandwave clearance). Environmental Statement volume 2, chapter 1: Marine Processes and volume 5, Annex 1.1: Marine Processes Technical Report provide a full description of the physical assessment, including the numerical modelling used to inform the predictions made with respect to increases in SSC and subsequent sediment deposition, with a summary of maximum design scenarios associated with this impact.

5.6.1.21 The maximum design scenario for increases in SSC associated with export cable installation are predicted to occur as a result of installation by mass flow excavator (see Table 4.1 and Environmental Statement volume 2, chapter 1: Marine Processes for full details). Disturbance of medium to coarse sand and gravels during cable installation are likely to result in a temporally and spatially limited plume affecting SSC levels (and settling out of suspension) near the point of release. SSC will be locally elevated within the plume close to active cable burial up to tens or hundreds of thousands of mg/l, although the change will only be present for a very short time locally (i.e. seconds to tens of seconds) before the material resettles to the seabed.

5.6.1.22 Depending on the height to which the material is ejected and the current speed at the time of release, changes in SSC and deposition will be spatially limited to within metres downstream of the cable for gravels and within tens of metres for sands. Finer material will be advected away from the release location by the prevailing tidal current. High initial concentrations (similar to sands and gravels) are to be expected but will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. Only a small proportion of the material disturbed is expected to be fines, with a corresponding reduction in the expected levels of SSC.

5.6.1.23 Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited (up to 6 m^3 per metre of cable burial) which also limits the combinations of sediment deposition thickness and extent that might realistically occur. The assessment presented in Environmental Statement volume 2, chapter 1: Marine Processes suggests that the extent and so the area of deposition will normally be much smaller for sands and gravels, leading to a greater average thickness of deposition in the order of tens of centimetres to a few metres in the immediate vicinity of the cable trench. Fine material, by contrast, will be distributed much more widely, becoming so dispersed that it is unlikely to settle in measurable thickness locally.

5.6.1.24 As detailed in Table 4.1, sandwave clearance is also expected to be required along the Hornsea Three offshore cable corridor (Environmental Statement volume 4, annex 3.6 Sediment Disposal: Site Characterisation) including within the North Norfolk Sandbanks and Saturn Reef SAC. Increases in SSC and subsequent deposition are therefore related to the passive phase of the plume comprised of finer sediments which are likely to stay in suspension and therefore will affect a larger area.

5.6.1.25 The impact to the subtidal qualifying Annex I habitats of the North Norfolk Sandbanks and Saturn Reef SAC from cable installation, including sandwave clearance, is predicted to occur at discrete locations within the SAC although the activity will be undertaken within kilometres of Hornsea Three (i.e. on a regional spatial scale) sandwave clearance will be incremental (one at a time) so that the extent of the impact at any given time will be minimised, of short term and intermittent duration, and reversible to baseline conditions following cessation of activities.

5.6.1.26 In relation to the fauna supported by SAC habitats, sandbanks, and sandy sediments in general, have very low to almost no sensitivity to increased SSC and smothering as a result of deposition. These conditions are a natural feature of the environment in which these habitats occur and as the majority of the characterising species are burrowing infaunal polychaetes these species are unlikely to be affected by smothering (De-Bastos and Hill, 2016; Tillin and Rayment, 2016; Tillin, 2016c).

5.6.1.27 *S. spinulosa*, which is a feature of Annex I reefs of the North Norfolk Sandbanks and Saturn Reef SAC, is tolerant of increased SSC (Tillin and Marshall, 2015). Experimental evidence relating to the burial tolerance of *S. spinulosa* has demonstrated that short term (<32 days) burial to depths of up to 7 cm has no effect on survival (Last *et al.*, 2011). Therefore the limited amount of sediment deposition by fine sediment predicted to result from cable installation, including sandwave clearance, is likely to be well within the tolerance of *S. spinulosa*. Recoverability from smothering is considered to be high (Tillin and Marshall, 2015). Pearce *et al.* (2007) found that *S. spinulosa* was present around the periphery of the Hastings Shingle Bank dredge site where sediments were being moved in all directions. This provides supporting evidence that suspended sediments released during dredging, which have been reported at other aggregate extraction sites in the English Channel at levels up to 5.5 g/l within 100 m of the dredger (Hitchcock and Bell, 2004), is not damaging to *S. spinulosa* aggregations, and could in fact enhance them as the worms rely on suspended sediments as a source of both food and building material (Pearce *et al.*, 2007).

<u>Conclusion</u>

5.6.1.28 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1, in relation to temporary increases in suspended sediments/smothering. There is no indication that temporary increases in suspended sediments/smothering would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Nor is there any indication that these effects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Accidental pollution

5.6.1.29 There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.

5.6.1.30 The total additional number of construction-related vessel round trips to port expected because of construction activities over the construction period for the entire project is up to 10,774. The highest intensity of construction activities and subsequently the majority of vessel activity will be occuring within the project array area remote from the SAC. The magnitude of the impact of this increase will be dependent on the quantities of potential pollutants carried by construction. Although many of the large construction vessels may contain large quantities of diesel oil, any accidental spill from vessels, vehicles, machinery or from construction activities would be subject to immediate dilution and rapid dispersal in the high energy environment found within the subtidal parts of Hornsea Three.

5.6.1.31 The levels of contaminants that subtidal receptors are likely to be exposed to as a result of accidental pollution is likely to be much lower than the benchmarks used in MarLIN to determine sensitivity due to the large dilution and dispersion that would occur offshore. Therefore, the sensitivity of benthic receptors to the levels of pollution is likely to be lower than that described here using the MarLIN benchmarks.

5.6.1.32 Given the designed-in mitigation (Table 4.5) the likelihood of accidental release is considered to be extremely low. Adherence to the mitigation (i.e. a PEMMP) and best working practices will significantly reduce the likelihood of an accidental pollution incident occurring. The likelihood of an accident between vessels resulting in an accidental spill during the construction period will be further reduced by the HSE MS which will be developed and implemented by Ørsted which incorporates the elements of the ASMS, as required by MGN 543. This will be particularly focused on ensuring safety of navigation within proximity of the offshore wind farm (see Environmental Statement, volume 2, chapter 7: shipping and navigation) but will also apply to activities associated with cable installation occurring within the SAC.

5.6.1.33 With respect to the Conservation Objectives for the SAC, therefore, there is no indication that an accidental pollution event of the type assessed here will lead to anything other than a very minor temporary reduction in environmental quality. It is not considered that any accidental pollution events associated with Hornsea Three would inhibit natural environmental processes or lead to a reduction in habitat extent. In terms of the fauna supported by these habitats, there is no indication that accidental pollution would adversely affect the physical structure of the habitats, reduce diversity, community structure or lead to any changes in the typical species that are representative of the Annex I habitats for which the SAC is designated.

<u>Conclusion</u>

5.6.1.34 Provided published guidelines, best working practices and the mitigation measures outlined in Table 4.5 are adhered to, the likelihood of an accidental spill is extremely low and, in the event of a spill, the volumes of potential contaminants released would be small and rapidly dispersed to concentrations below which deleterious effects would be expected. Consequently, significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1, in relation to accidental pollution.

5.6.1.35 There is no indication that accidental pollution would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Nor is there any indication that these effects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

5.6.2 Potential impacts - operation and maintenance

Permanent/long term habitat loss

5.6.2.1 It is predicted that there will be some loss of habitat directly under export cables where cable protection is required.

5.6.2.2 As per the temporary habitat loss/disturbance assessment during construction phase, assessed above, it was agreed with the JNCC (EWG) that when assessing this impact on the North Norfolk Sandbanks and Saturn Reef SAC it should be assumed that the sites qualifying Annex I habitat features are present across the entire area of the site.

5.6.2.3 Of the total permanent/long term habitat loss predicted for Hornsea Three (Table 4.1) up to 497,400 m^2 of this is predicted to affect the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from cable protection where burial is not possible and pipeline/cable crossings). (Table 5.8). This represents 0.01% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. all potential Annex I sandbank habitat). Cable protection requirements along the Hornsea Three offshore cable corridor will be detailed in the Cable Specification and Installation Plan which will be produced prior to construction and agreed with the MMO.

Table 5.8: Maximum permanent/long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC.

Project Element	Total maximum permanent/long term habitat loss (m^2)	Assumptions
Cable protection associated with export cables	197,400 m^2	Assumes a maximum of 10% of the total length of 282 km of export cables within the North Norfolk Sandbanks and Saturn Reef SAC (up to six cables each of up to 47 km in length) will require cable protection, affecting a corridor of up to 7 m width.
Cable protection associated with cable/pipeline crossings	300,000 m^2	Assumes up to 20 crossings per cable within the North Norfolk Sandbanks and Saturn Reef SAC, with long term habitat loss of up to 2,500 m^2.
Total permanent/long term habitat loss	497,400 m^2	

5.6.2.4 The Hornsea Three offshore cable corridor coincides with the delineated boundary of *S. spinulosa* reef in the North Norfolk Sandbanks and Saturn Reef SAC (Figure 5.5), although no reefs were identified within the Hornsea Three benthic ecology study area coinciding with the North Norfolk Sandbanks and Saturn Reef SAC during the site specific surveys. However, should Annex I *S. spinulosa* reef be present in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be discussed with statutory consultees to avoid direct impacts to these reefs from cable protection, where possible (see Table 5.5). For this reason, figures for permanent/long term habitat loss of this Annex I reef habitat are not presented in this section or in Table 5.8.

5.6.2.5 The impact of permanent/long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC, with no predicted effects on qualifying Annex I reef habitats.

5.6.2.6 Hornsea Three will employ sensitive cable protection within the areas of designated sites that coincide with Hornsea Three which will consider the local seabed conditions, including sediment/substrate type. These cable protection measures will not include concrete mattresses (see Table 4.5). Hornsea Three will discuss and agree the precise nature of these measures for the North Norfolk Sandbanks and Saturn Reef SAC with the MMO through sign of on the Cable Specification and Installation Plan prior to construction. This may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes (e.g. coarse gravel, cobbles and boulders) known to occur naturally within the SAC. Where such measures can be employed, these may allow local communities associated with the habitat features of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. infaunal communities where sediment accumulation occurs; epifaunal in the case of appropriate rock protection) to colonise these areas, potentially providing some recovery of communities in areas where cable protection is placed and reducing the extent of permanent/long term habitat loss in the North Norfolk Sandbanks and Saturn Reef SAC.

5.6.2.7 It is acknowledged that the presence of the cable protection within the North Norfolk Sandbanks and Saturn Reef SAC may serve as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. However, due to the mobile nature of sediments in the area, is it expected that at times, the cable protection will be partially or completely covered by naturally occurring sediment. The MarESA for the SspiMx biotope does note that *S. spinulosa* has been recorded colonising bedrock and artificial structures. Therefore, an increase in the availability of hard substratum may be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different (Tillin and Marshall, 2015). This, together with the designed-in mitigation to employ sensitive cable protection in the SAC (see Table 4.5) means it is not considered that the presence of cable protection within the North Norfolk Sandbanks and Saturn Reef SAC will preclude the establishment of Annex I reefs, or indeed Annex I 'Sandbanks which are slightly covered by seawater all the time' in these areas in the future.

5.6.2.8 With respect to the Conservation Objectives for the SAC, there is no indication that permanent/long term habitat loss will lead to a reduction in environmental quality, nor will it inhibit natural environmental processes. It is predicted that there will be a slight loss of habitat extent, however, this represents only 0.01% of the Annex I habitat features within the SAC and would result in an insignificant change in the baseline condition.

5.6.2.9 The impact will result in localised changes in the physical structure of the habitat and the loss of associated species that rely upon those habitats. As the extent of these effects is very limited, however, within the context of the SAC, it is not predicted that these changes will lead to a significant or widespread reduction in diversity, community structure or the typical species associated with the Annex I habitats present.

Conclusion

5.6.2.10 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1, in relation to permanent/long term habitat loss.

5.6.2.11 There is no indication that the predicted localised permanent/long term habitat loss would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats especially when considering the dynamic and transient nature of these habitats. Additionally, there is no indication that localised permanent/long term habitat loss would lead to any significant adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, it is concluded that there will be no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact.

Colonisation of hard structures and INNS

5.6.2.12 The introduction of up to 544,123 m^2 of surface area of new hard substrate is predicted to occur as a result of cable protection for up to 10% of 282 km of export cable within the North Norfolk Sandbanks and Saturn Reef SAC (six cables of up to 47 km in length) as well as up to 20 cable/pipeline crossings per cable (Table 5.9). Associated increases in biodiversity will potentially affect up to 0.015% of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'. This impact is not predicted to affect any Annex I reef features of the North Norfolk Sandbanks and Saturn Reef SAC as no reefs were identified within the Hornsea Three benthic ecology study area coinciding with the North Norfolk Sandbanks and Saturn Reef SAC during the site specific surveys, however, the surveys did identify existing hard substrates in some areas of the site. In a habitat where encrusting epifaunal species are rare, this is likely to represent highly localised shifts in the baseline conditions.

Table 5.9: Maximum surface area from introduction of hard substrate within the North Norfolk sandbanks and Saturn Reef SAC during the operational phase.

Project Element	Total surface area (m^2)	Assumptions
Cable protection associated with export cables	244,123 m^2	Assumes a maximum of 10% of the total length of 282 km of export cables within the North Norfolk Sandbanks and Saturn Reef SAC (up to six cables each of up to 47 km in length) will require cable protection. Assumes an up to 7 m wide cable corridor, cable protection to an indicative height of up to 2 m and a berm 3 m wide at the top, giving a per metre surface area of approximately 8.7 m^2.
Cable protection associated with cable/pipeline crossings	300,000 m^2	Assumes up to 20 crossings per export cable within the North Norfolk Sandbanks and Saturn Reef SAC, with habitat creation of up to 2,500 m^2.
Total surface area of introduced habitat	544,123 m^2	-

5.6.2.13 The introduction of hard substrate into a predominantly soft sediment area can facilitate the spread of non-native species which may predate on, and compete with, existing native species (Inger *et al.*, 2009). Recent studies have demonstrated the potential for offshore renewable energy devices to act as ecological 'stepping stones', facilitating the spread of pelagic larval particles that would otherwise have been lost offshore and allowing the transgression of natural biogeographical boundaries (Adams *et al.*, 2014). However, there is little evidence from post construction monitoring undertaken to date to suggest that the hard structures associated with offshore wind farms provide any new or unique opportunities for non-indigenous species which could facilitate their introduction (Linley *et al.*, 2007).

5.6.2.14 The risks of introduction and spread of INNS during both the construction, and operation and maintenance phases have been considered and this assessment is considered to be equivalent to the following pressure identified by the ICGC pressures list under the overarching pressure theme 'Biological pressures':

- Introduction or spread of non-indigenous species.

5.6.2.15 The benchmark for the relevant MarESA pressure (of the same name) which has been used to inform this impact assessment is the direct or indirect introduction of one or more INNS.

5.6.2.16 The impact from construction vessels has been considered together with the impact during the operation and maintenance phase because the majority of this impact will arise as a result of the introduction of hard substrate associated with foundations and cable/scour protection with a smaller potential contribution from vessel movements.

5.6.2.17 There will be up to 10,774 round trips to port during the construction phase and up to 2,885 round trips to port by operational and maintenance vessels, which will contribute to the risk of introduction or spread of INNS in ballast water. The highest intensity of construction activities and subsequently the majority of vessel activity will be occuring within the project array area remote from the SAC. Designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will, however, ensure that the risk of potential introduction and spread of INNS will be minimised.

5.6.2.18 Habitats along the Hornsea Three offshore cable corridor, including within North Norfolk Sandbanks and Saturn Reef SAC, are likely to be subjected to a lower risk of INNS introduction than the array area as only export cables will be present and the cable will be buried for the most part.

5.6.2.19 Additionally, the risk of introduction of INNS by ballast water will be considerably lower along the cable corridor than at the Hornsea Three array, as only a limited number of round trips by operational and maintenance vessels will be required for the Hornsea Three offshore cable corridor and over a greater geographic area.

5.6.2.20 Any impact on the qualifying features in the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be of local spatial extent (though the introduction of structures may serve as 'stepping stones' and extend the impact on a regional, national, or international scale (however it is not possible to predict such a spread), long term duration (35 years - lifetime of Hornsea Three), continuous and irreversible. However, the sandbank and reefs habitats of the North Norfolk sandbanks and Saturn Reef SAC are considered to have low vulnerability to this potential impact.

5.6.2.21 Although the introduction of some INNS could lead to changes in the diversity and structure of faunal communities, the risk of this significantly affecting the Annex I habitats of North Norfolk Sandbanks and Saturn Reef SAC due to the colonisation of hard structures introduced into the SAC due to Hornsea Three is considered to be very slight. There being no indication that similar developments elsewhere in British waters have led to the introduction of INNS.

Conclusion

5.6.2.22 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1 in relation to the colonisation of hard structures and potential introduction of INNS.

5.6.2.23 There is no indication that the colonisation of hard structures would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication of a significant risk that of an introduction of INNS leading to an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Changes in physical processes

Wave regime

5.6.2.24 The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on offshore sandbanks including Annex I 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC. The results of the wave modelling predict a general reduction in wave height in the region of the north Norfolk sandbanks when waves are coming from the north, north northeast and north east, which is about 15% of the time. During these conditions, there may be a small reduction in wave height of up to 15% within the vicinity of the Indefatigable Bank system and up to ~2% within the vicinity of sandbanks closer inshore (e.g. Ower Bank; see Environmental Statement volume 5, annex 1.1: Marine Processes Technical Annex). Whilst impacts to sandbanks could theoretically occur throughout the operational lifetime (i.e. 35 years) of Hornsea Three (i.e. be of long term duration), any impacts would be intermittent in nature.

5.6.2.25 With respect to current effects, the presence of Hornsea Three would result in near-field effects only (i.e. primarily within the offshore wind farm footprint), largely spatially limited to within the Hornsea Three array area and a narrow region just outside of the boundary (in the order of 4 km; see ES chapter 1: Marine Processes) which would not affect Annex I habitat interest features at North Norfolk Sandbanks and Saturn Reef SAC. Furthermore, cable protection along the offshore cable corridor and within the Hornsea Three array area and the presence of a HVAC booster station will only exert a highly localised influence on near-bed tidal currents.

5.6.2.26 Subtidal mobile sandbanks are subject to continued reworking of the sediment by wave action and tidal streams and thus are dominated by species capable of tolerating severe changes in the hydro-physical regime (Elliott *et al.,* 1998). The sandy communities recorded along the Hornsea Three offshore cable corridor within the North Norfolk Sandbanks and Saturn Reef SAC comprised biotopes that represent communities comprising low infaunal and epifaunal diversity, namely the NcirBat and ApriBatPo biotopes (see Figure 5.4 and Environmental Statement volume 5, annex 2.1: Benthic Ecology Technical Report), in addition the biotope IMoSa has also been recorded at the sandbanks (Jenkins *et al.,* 2015). The sandy communities associated with the sandbanks in this designated site are typically sparse and dominated by *Bathyporeia spp*. and *Nephtys cirrosa* (Jenkins *et al.,* 2015). The NcirBat biotope is not sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016a). Mobile sands characterise this biotope and water movement is therefore an important physical parameter for this biotope, largely as wave action rather than tidal flow, however an increase in flow-related disturbance could shift the community assemblage to one characteristic of the IMoSa biotope, while a decrease can alter NcirBat to the FfabMag biotope (Tillin, 2016a).

5.6.2.27 Similarly, the ApriBatPo biotope is not considered to be sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016d). Characteristic species may be associated with troughs and crests of rippled bedforms which are created by the tidal flow and wave action, therefore this biotope may emerge following an increase in water flow, or disappear following a reduction in flow (Tillin, 2016d). The tidal currents across the former Hornsea Zone vary from approximately 0.6 ms^{-1} to 1 ms^{-1}. ApriBatPo occurs in flow strengths of between <0.5 ms^{-1} and 1.5 $ms^{-1,}$ therefore the predicted maximum changes in current speeds resulting from Hornsea of +0.04 ms^{-1} to -0.1 ms^{-1} would be unlikely to cause the ApriBat biotope to disappear.

5.6.2.28 *S. spinulosa* is tolerant of local changes in tidal current flow and local changes in wave exposure (Tillin and Marshall, 2015). As such, Annex I *S. spinulosa* reefs are not considered to be sensitive to these effects.

Sediment transport

5.6.2.29 Installation of cable protection could result in a local elevation of the seabed profile by up to 2 m (Environmental Statement volume 2, chapter 1: Marine Processes). Cable protection would be placed onto the seabed surface above the cable and therefore could present an obstacle to sediment transport, trapping sediment locally and thereby impacting down-drift locations through a reduction in sediment supply.

5.6.2.30 The JNCC recently commissioned an investigation into the possible impacts of rock dump from oil and gas decommissioning on Annex I mobile sandbanks in the North Norfolk Sandbanks and Saturn Reef SAC (JNCC, 2017a). Although the dimensions (i.e. height and width) of rock dump associated with oil & gas infrastructure is likely to be slightly greater for pipelines than for cables, the principles regarding the potential for interaction with naturally occurring sediment transport pathways remain the same. Accordingly, conclusions from the JNCC study are of relevance here. JNCC (2017a) identified that:

'…there is currently insufficient information to quantify or qualify the implications of rock dump in the North Norfolk Sandbanks and Saturn Reef [SAC] from a physical (and biological) perspective. It is not possible to quantify or qualify the movement of sandbanks around or over existing or applied rock dump. Theoretically, the mobile sandbanks may cyclically cover applied rock dump and there is the potential for scour to be induced if an appropriate design is not chosen. Without further information on rock berm design, monitoring studies and numerical modelling of such behaviour, the short-term and long-term implications of both theoretical behaviours are difficult to determine.'

5.6.2.31 No additional observational data or information has been found to inform this assessment, since the publication of JNCC (2017a). Further details can be found in Environmental Statement volume 1, chapter 11: Marine Processes

5.6.2.32 Potential effects on sediment transport can only occur following installation of the cable protection and under conditions where sediment is being actively transported in a manner that is both susceptible to such blockage and in a direction that intersects the cable protection. The potential magnitude of any effect is correspondingly reduced if and when the rate of transport is naturally low, if the mode of sediment transport includes a larger proportion of material in high saltation or suspension, and/or where the axis of the cable protection and the local direction of sediment transport are relatively more aligned.

5.6.2.33 At worst, the obstacle presented by the cable protection will locally prevent the onward passage of all sediment in transport, causing that sediment to accumulate locally. As the accumulated sediment volume increases, any open voids in the protection would become infilled and a sediment slope would develop on the updrift side (with a maximum slope angle equal to the angle of repose for sand ~30 degrees). As the stable slope approaches the top of the protection (up to 2 m above the seabed), the blockage effect of the cable protection will be progressively reduced to near zero and sediment will subsequently be transported directly over the obstacle (via the sediment slope and/or in saltation or suspension) unimpeded, at the naturally occurring ambient rate and direction. Further information can be found in Environmental Statement volume 1, chapter 11: Marine Processes.

5.6.2.34 For all areas in which cable protection is used (including where sandwaves are present), it is expected that the total volume of sediment supply intercepted by the protection (and so the scale of any consequential effects on seabed morphology downstream) will be very small in both absolute and relative terms. The presence of cable protection will not continue to affect patterns of sediment transport beyond the initial period of accumulation. It is also noted that cable protection measures will only be present locally where required and will not present a continuous blockage along the whole cable route corridor.In summary, any impacts on sandbanks arising from changes to the sediment transport regime are predicted to be of very limited local spatial extent and magnitude, continuous and reversible.

5.6.2.35 North Norfolk Sandbanks are considered to have high sensitivity to physical loss via obstruction, caused by the presence of structures. However, the majority of the North Norfolk sandbanks are dynamic and mobile and therefore considered to have moderate levels of recoverability enabling them to return to a state close to that which existed before any impact. Impacts associated with cable protection will only exert a highly localised influence, such that the magnitude is considered to be negligible.

5.6.2.36 Therefore, no effects are predicted on habitats within North Norfolk Sandbanks and Saturn Reef SAC, as a result of sediment transport changes.

5.6.2.37 There is no indication that any changes in physical processes arising from the operation of Hornsea Three would lead to significant changes in natural environmental quality, natural environmental processes or the extent of the qualifying Annex I habitats of the North Norfolk sandbanks and Saturn Reef SAC. Nor is there any indication that the physical structure, diversity, community structure or typical species of these features would be significantly changed.

<u>Conclusion</u>

5.6.2.38 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1, in relation to changes in physical processes.

5.6.2.39 There is no indication that changes in physical processes would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication that changes in physical processes would lead to an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Temporary seabed disturbance

5.6.2.40 Temporary disturbance/alteration of seabed habitats within the North Norfolk Sand and Saturn Reef SAC may occur during the operation and maintenance phase of Hornsea Three as a result of maintenance operations.

5.6.2.41 Of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance (Table 4.1), up to 849,851 m^2 of this is predicted to affect the Annex I 'Sandbanks which are slightly covered by seawater all the time' habitat within the North Norfolk Sandbanks and Saturn Reef SAC over the 35 year design life. This equates to 0.02% of the extent of this Annex I habitat within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. assuming all sediment within the SAC is assigned to Annex I sandbank habitat; JNCC, 2010). It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 29% of the total export cable length coincides with the North Norfolk Sandbanks and Saturn Reef SAC, 29% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. Temporary disturbance to Annex I reef features within this site will be avoided where possible to minimise any direct impacts and, based on the current distribution of habitats within the Hornsea Three offshore cable corridor, impacts to Annex I reef habitat are not predicted.

<u>Conclusion</u>

5.6.2.42 Significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1 in relation to temporary seabed disturbance.

5.6.2.43 There is no indication that temporary seabed disturbance would adversely affect the ability for the Conservation Objectives of this SAC to be achieved with regards to the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Additionally, there is no indication that temporary seabed disturbance would lead to an adverse change to the physical structure, biological diversity or community structure of typical species that are representative of Annex I sandbanks which are slightly covered by seawater all the time or Annex I reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Accidental pollution

5.6.2.44 There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves. The release of such contaminants may lead to impacts on the benthic communities present, through toxic effects resulting in reduced benthic diversity, abundance and biomass.

5.6.2.45 The magnitude of the impact is entirely dependent on the nature of the pollution incident but the SEA carried out by DECC (2011) recognised that, "renewable energy developments have a generally limited potential for accidental loss of containment of hydrocarbons and chemicals, due to the relatively small inventories contained on the installations (principally hydraulic, gearbox and other lubricating oils, depending on the type of installation)". Such sources are present only in the array area and do not represent a hazard to any Natura 2000 Site.

5.6.2.46 A potential for accidental spills will also occur as a result of the 2,885 round trips to port by maintenance and operational vessels and up to 4,671 round trips by helicopter per year over the 35 year design life of Hornsea Three (Table 4.1). However, as most of these vessels will be crew/supply vessels and helicopters servicing the array area, these will be typically small and will therefore be carrying only limited amounts of potential contaminants and remote from the SAC. Although larger operational and maintenance vessels may contain larger quantities of potential pollutants (e.g. jack up vessels) such as diesel oil, movements of these vessels will be far fewer in comparison to smaller vessels.

5.6.2.47 Throughout operation there will be the requirement to store fuel offshore for the purposes of refuelling CTVs and/or helicopters, this storage will be on up to three of the offshore accommodation platform barges. An impact on benthic ecology receptors would only be realised if an incident occurs where the fuel is accidentally released. The historical frequency of pollution events in the southern North Sea benthic ecology study area is low considering the density of existing marine traffic in the area. Given the designed-in mitigation which is proposed, it is considered that the likelihood of accidental release is extremely low. Furthermore, the likelihood of a collision between vessels resulting in an accidental spill during the operation and maintenance period will be further reduced by the HSE MS which will be developed and implemented by Ørsted which incorporates the elements of the ASMS, as required by MGN 543 (see Environmental Statement, volume 2, chapter 7: Shipping and Navigation).

5.6.2.48 The risk of an accidental pollution event upon subtidal benthic receptors and subsequently the qualifying Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC, is predicted to be of local to regional spatial extent, short term duration (i.e. in the unlikely event that a spillage occurs, the impact would last hours to days), intermittent and reversible. It is predicted that the impact would affect SAC features directly and/or indirectly, but that the likelihood of an accidental pollution incident occurring is very small..

<u>Conclusion</u>

5.6.2.49 Provided published guidelines, best working practices and the mitigation measures outlined in Table 4.5 are adhered to, the likelihood of an accidental spill is extremely low and, in the event of a spill, the volumes of potential contaminants released would be small and rapidly dispersed to concentrations below which deleterious effects would be expected. Consequently, significant impacts are not anticipated to arise as a result of Hornsea Three on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC identified in Table 5.1, in relation to accidental pollution during operation and maintenance.

5.6.2.50 There is no indication that accidental pollution would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats. Nor is there any indication that these effects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Such sources are present only in the array area and do not represent a hazard to any Natura 2000 Site.

Future monitoring

5.6.2.51 Table 5.10 and Table 5.11 below outline the proposed monitoring commitments for benthic ecology.

Table 5.10: Construction phase monitoring commitments

Environmental effect	Monitoring commitment
The Hornsea Three assessment assumes that, where possible, there will be no direct impacts (i.e. from temporary, long term and permanent habitat loss) to Annex I reefs within the Hornsea offshore cable corridor on the basis of the designed-in mitigation measures.	As outlined in the IPMP (document reference number 8.8), to ensure where possible no direct impacts to Annex I reef habitat, a survey will be undertaken along the Hornsea Three offshore cable corridor prior to construction to determine the location, extent and composition of any benthic habitats of conservation or ecological importance (i.e. Annex I reefs), the exact scope of which will be agreed with the relevant statutory consultees. Any requirement for construction monitoring beyond that proposed for the designed-in mitigation will be outlined in the IPMP (document reference number 8.8) and will be targeted to areas of uncertainty and features of designated sites.

Table 5.11: Operation and maintenance phase monitoring commitments.

Environmental effect	Monitoring commitment
Monitoring is deemed necessary during the operation and maintenance phase to determine the effectiveness of the designed-in mitigation measures proposed for sensitive cable protection within designated sites.	As outlined in the IPMP (document reference number 8.8), Hornsea Three will undertake monitoring of a representative proportion of the Hornsea Three offshore cable corridor within designated sites (i.e. North Norfolk Sandbanks and Saturn Reef SAC, The Wash and North Norfolk coast SAC, Cromer Shoal Chalk Beds MCZ and Markham's Triangle rMCZ) in areas where sensitive cable protection material is employed. The aim of the surveys will be to determine the success of sensitive cable protection measures within designated sites by monitoring the behaviour/recovery of the sediments associated with the cable protection over an agreed period of time and by monitoring any recolonisation/recovery of the associated benthic communities. It is likely that the surveys will be undertaken by a combination of geophysical survey and Remote Operated Vehicle (ROV) survey, however, the details of the survey will be agreed with the statutory consultees.

5.7 In-combination assessment methodology

5.7.1 Screening of other projects and plans into the in-combination assessment

5.7.1.1 The in-combination assessment considers the impacts associated with Hornsea Three together with other projects and plans. The projects and plans selected as relevant to the assessments within the RIAA were initially identified from the results of a screening exercise undertaken for the Environmental Statement (see Environmental Statement volume 4, annex 5.2: Cumulative Effects Screening Matrix and volume 4, annex 5.3: Location of Schemes) and then each project on the CEA long list has been considered on a case by case basis for screening in or out of this RIAA upon data confidence, effect-receptor pathways and the spatial/temporal scales involved. Section 4.4 details the approach to the in-combination assessment.

5.7.1.2 The specific projects scoped into this in-combination assessment are outlined in Table 5.12 and shown in Figure 5.7. The projects included as operational in this assessment have been commissioned since the baseline studies for this project were undertaken and as such were excluded from the baseline assessment.

5.7.2 Maximum design scenario

5.7.2.1 The in-combination impacts presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (Environmental Statement volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, in order to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

5.7.3 In-combination screening conclusions

5.7.3.1 Where an impact pathway has been identified, the maximum design scenarios have been selected as those having the potential to result in the greatest effect on the screened in qualifying Annex I habitat features of The Wash and North Norfolk Coast SAC and the North Norfolk Sandbanks and Saturn Reef SAC.

5.7.3.2 The plans and projects screened in have then been considered on a case by case basis to determine whether the potential for an in-combination effect exists.

5.7.3.3 A number of impacts set out in Table 5.3 have not been considered in the in-combination assessment. This is because many of the potential impacts identified and assessed for Hornsea Three alone are relatively localised and temporary in nature and therefore have limited or no potential to interact with similar changes associated with other projects. Many of the potential impacts considered within the Hornsea Three alone assessment are specific to a particular project phase (e.g. construction/operation). The potential for cumulative effects with other projects only have the potential to occur if the activities causing the change spatially or temporally overlap. Of the impacts set out in Table 5.3 the following have not been considered in the in-combination assessment due to the highly localised nature of some of the impacts (i.e. within the Hornsea Three boundary only) and/or because the potential significance of impact has been assessed as negligible for Hornsea Three offshore wind farm alone:

- Construction Phase:
  - Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.
- Operation and Maintenance Phase:
  - Colonisation of hard structures and increased risk of introduction or spread of INNS due to presence of subsea infrastructure and vessel movements (e.g. ballast water) may affect benthic ecology and biodiversity;
  - Maintenance operations may result in temporary seabed disturbances and potential effects on benthic ecology; and
  - Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.

5.7.3.4 The projects/plans identified as having potential impacts in-combination with Hornsea Three on the Annex I habitat features of the North Norfolk sandbanks and Saturn Reef SAC are described in Table 5.12 and shown in Figure 5.7. There are no plans or projects screened in for in-combination assessment of the impacts identified with The Wash and North Norfolk Coast SAC.

Table 5.12: List of other projects and plans with potential for in-combination effects.

European Site	Hornsea Three Phase	Potential Impact	In-combination Screening Criteria	Project/Plans Identified for in-combination assessment	Plan/Project Phase	Plan/Project Type	Details	Distance from Hornsea Three cable corridor	Distance from North Norfolk Sandbanks and Saturn Reef SAC	Screened in for in-combination assessment
North Norfolk Sandbanks and Saturn Reef	Construction	In-combination temporary habitat loss/disturbance of Annex I sandbank or reef habitat	Maximum additive temporary habitat loss is calculated for all plans/projects that may result in temporary habitat loss/disturbance that overlap with the North Norfolk Sandbanks and Saturn Reef SAC.	**Tier 1**						
				Humber 3 - 484	Operational (with on-going effects)	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	0 km	0 km	Yes
				Leman BH	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	34 km	0 Km	Yes
				Viking Charlie Drilling (CD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	22 km	0 Km	Yes
				Viking Delta Drilling (DD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	21 km	0 Km	Yes
				Viking Echo Drilling (ED	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	12 km	0 Km	Yes
				Viking Golf Drilling (GD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	15 km	0 Km	Yes
				Viking Hotel Drilling (HD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	13 km	0 Km	Yes
				Vulcan UR	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	12.9 km	0 Km	Yes
				Viscount VO	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	15 km	0 Km	Yes

European Site	Hornsea Three Phase	Potential Impact	In-combination Screening Criteria	Project/Plans Identified for in-combination assessment	Plan/Project Phase	Plan/Project Type	Details	Distance from Hornsea Three cable corridor	Distance from North Norfolk Sandbanks and Saturn Reef SAC	Screened in for in-combination assessment
				Vampire/Valkyrie	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	4 km	0 Km	Yes
				Audrey A (WD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	1 km	0 Km	Yes
				Audrey B (XW)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	6 km	0 Km	Yes
				PL496	Operational	Pipelines associated with Audrey field	Decommissioning activity overlapping with Hornsea Three construction	0	0 Km	Yes
				PL497				0	0 Km	Yes
				PL723				1.3 km	0 Km	Yes
				PL724				1.3 km	0 Km	Yes
				PL575				1.3 km	0 Km	Yes
				PL576				1.3 km	0 Km	Yes
				Tier 2						
				Humber 5 - 483	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	2 km	0 Km	Yes
		Temporary increases in suspended sediment concentrations and associated sediment deposition from cable and foundation installation and seabed preparation during the construction phase may affect Annex I	Changes in SSC and deposition will be spatially limited to within metres downstream of the cable for gravels and within tens of metres for sands and finer material will be advected away from the release location by the prevailing tidal current. High initial concentrations (similar to sands and gravels) are to be expected but will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. Only a small proportion of the material disturbed is expected to be fines, with a corresponding reduction in the expected levels of SSC ES Chapter 1: Marine Processes and volume 5, annex 1.1: Marine Processes Technical Report. For this reason the existing 10 km marine processes buffer has conservatively been applied.	**Tier 1**						
				Humber 3 - 484	Operational (with on-going effects)	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	0 km	0 km	Yes
				Tier 2						
				Humber 5 - 483	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	2 km	0 km	Yes

European Site	Hornsea Three Phase	Potential Impact	In-combination Screening Criteria	Project/Plans Identified for in-combination assessment	Plan/Project Phase	Plan/Project Type	Details	Distance from Hornsea Three cable corridor	Distance from North Norfolk Sandbanks and Saturn Reef SAC	Screened in for in-combination assessment
		sandbank or reef habitat.	Therefore, maximum additive effects all plans/projects occurring within the North Norfolk Sandbanks and Saturn Reef SAC and any plan/projects occurring within the 10 km marine processes buffer of the cable corridor that are also with 10 km of a European site boundary with qualifying Annex I habitat features.	Humber 4 and 7 - 506	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	8 km	8.5 km	Yes
	Operation	In-combination permanent/long term loss of Annex I sandbank or reef habitat through presence of offshore wind farm infrastructure (e.g. cable protection, substations) and oil and gas and interconnector installations.	Maximum additive effects calculated for all plans/projects that may result in permanent/long term habitat loss that overlap with the North Norfolk Sandbanks and Saturn Reef SAC.	**Tier 1**						
				Audrey A (WD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	1 km	0 Km	Yes
				Audrey B (XW)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	6 km	0 Km	Yes
				Viking Charlie Drilling (CD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	22 km	0 Km	Yes
				Viking Delta Drilling (DD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	21 km	0 Km	Yes
				Viking Echo Drilling (ED	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	12 km	0 Km	Yes
				Viking Golf Drilling (GD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	15 km	0 Km	Yes
				Viking Hotel Drilling (HD)	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	13 km	0 Km	Yes

European Site	Hornsea Three Phase	Potential Impact	In-combination Screening Criteria	Project/Plans Identified for in-combination assessment	Plan/Project Phase	Plan/Project Type	Details	Distance from Hornsea Three cable corridor	Distance from North Norfolk Sandbanks and Saturn Reef SAC	Screened in for in-combination assessment
				Vulcan UR	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	12.9 km	0 Km	Yes
				Viscount VO	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	15 km	0 Km	Yes
				Vampire/Valkyrie	Operational	Gas platform	Decommissioning activity overlapping with Hornsea Three construction	4 km	0 Km	Yes

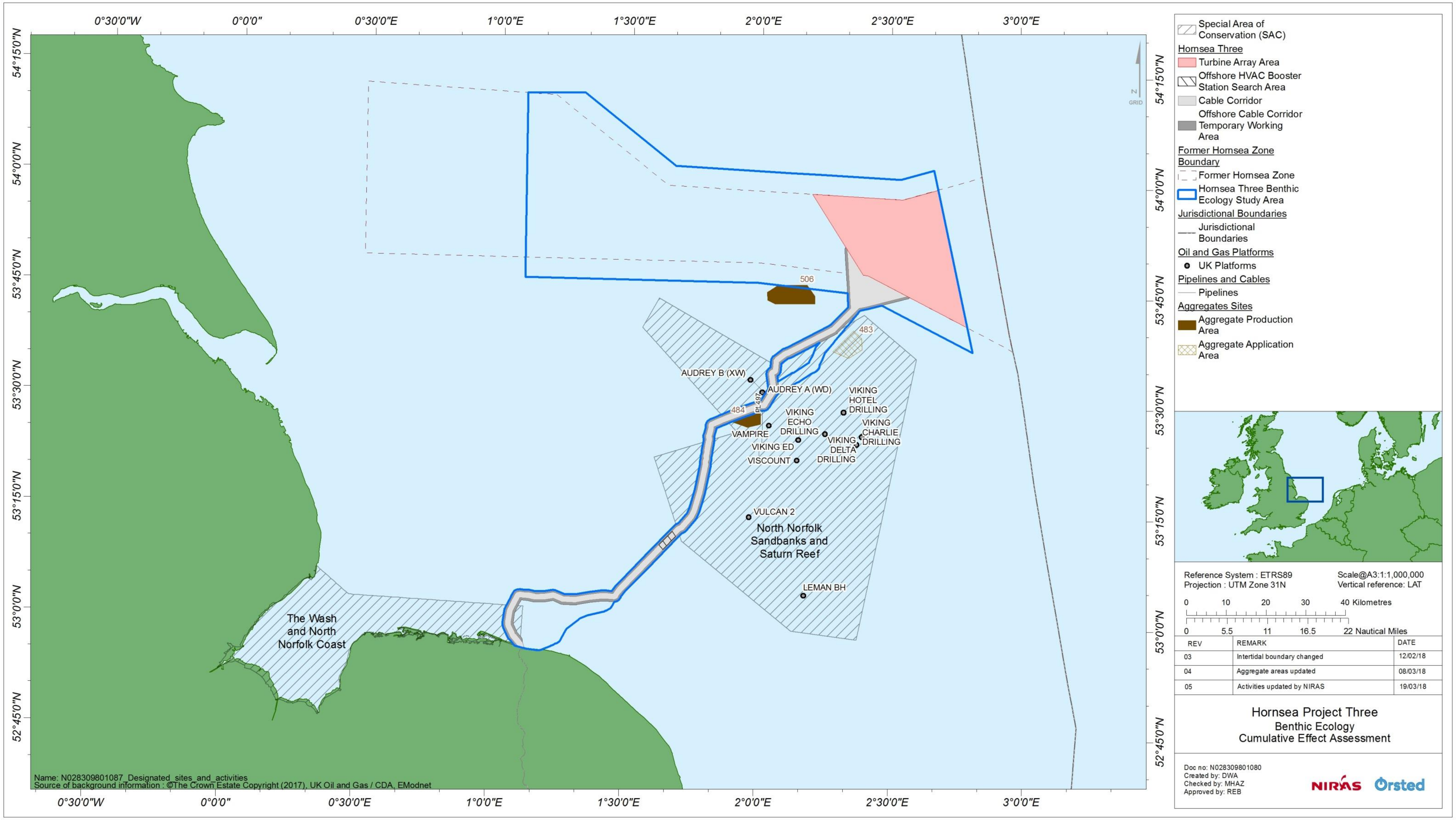


Figure 5.7: Offshore project/plans/activities screened into the in-combination assessment.

5.8 The Wash and North Norfolk Coast SAC Assessment of potential adverse effect on site integrity in-combination with other plans and projects

5.8.1.1 A description of in-combination assessment upon Annex I sandbank and reef habitat features of The Wash and North Norfolk Coast SAC arising from each identified potential impact is given below.

5.8.2 Construction/decommissioning

Temporary habitat loss/disturbance

5.8.2.1 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within The Wash and North Norfolk Coast SAC that may contribute to cumulative temporary habitat loss with Hornsea Three. Therefore, there is no cumulative assessment of temporary habitat loss for this site.

Temporary increases in suspended sediment

5.8.2.2 It was not considered likely that there would be an in-combination effects from any aggregate areas. This was checked against the aggregate assessments. Plume dispersion modelling results for area 484 (Figure 5.7) showed that the maximum extent of a turbid plume resulting from dredging activity would be 15.5 km. Plume dispersion modelling results for application area 483 (Figure 5.7) showed that the maximum extent of a turbid plume resulting from dredging activity would be 17.0 km (ABPmer, 2013). Therefore, there are no Tier 1 or Tier 2 plans or projects that have been identified with a ZoI that overlaps The Wash and North Norfolk Coast SAC that may contribute to and adverse impact and subsequently and adverse effect on site integrity from increased SSC.

5.8.3 Operation/maintenance

Permanent/long term habitat loss

5.8.3.1 There are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified within The Wash and North Norfolk Coast SAC that may contribute to an in-combination permanent/long term habitat loss with Hornsea Three. Therefore, there is no in-combination assessment of permanent/long term habitat loss for this site.

Changes to physical processes

5.8.3.2 Cumulative impacts will extend over the regional area but will, overall, be highly localised to within the individual project footprints. Scour effects associated with the presence of offshore wind farm structures likely to be highly localised and spatially restricted to the immediate vicinity of the structures within the offshore wind farm arrays. The duration of time over which potential wave interaction could occur is very small (Environmental Statement volume 5, annex 1.1: Marine Processes Technical Report). The assessment presented in volume 5, annex 1.1 Marine Processes Technical Report concludes that the cumulative reduction in wave height predicted due to the operational presence of other offshore wind farms are considered to be of very small magnitude and are not predicted to have any measurable effects on sediment transport.

5.8.3.3 Therefore, as there are no Tier 1, Tier 2 or Tier 3 plans or projects that have been identified that may contribute to in-combination effect on The Wash and North Norfolk Coast SAC with Hornsea Three andthere is no in-combination assessment of changes to physical processes for this site.

5.9 North Norfolk Sandbanks and Saturn Reef SAC Assessment of potential adverse effect on site integrity in-combination with other plans and projects

5.9.1.1 A description of in-combination assessment upon Annex I sandbank and reef habitat features of the North Norfolk Sandbanks and Saturn Reef SAC arising from each identified potential impact is given below.

5.9.1.2 As per the alone assessments it was agreed with the JNCC (EWG) that when assessing impacts on the North Norfolk Sandbanks and Saturn Reef SAC it should be assumed that the sites Annex I habitat qualifying features are present across the entire area of the site.

5.9.2 Construction/decommissioning

Temporary habitat loss/disturbance

5.9.2.1 There is the potential for temporary habitat loss as a result of construction activities associated with Hornsea Three in-combination with oil and gas decommissioning activities and aggregate extraction activities identified in Table 5.12.

5.9.2.2 With respect to cumulative temporary habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC, only those projects that are located within the site boundary are considered relevant for this impact. These include:

- Tier 1 projects:
  - Oil and Gas decommissioning associated with VDP1, LDP and the Leman field; and

- Licenced aggregate extraction areas: Area 484.
- Tier 2 projects:
  - Aggregation and extraction Application Area 483.

Table 5.13: Predicted temporary habitat loss for Hornsea Three and other plans/projects/activities within the North Norfolk Sandbanks and Saturn Reef SAC screened in for in-combination assessment.

Project	Total predicted temporary habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC (km^2)	Source
Hornsea Three	9.31	See alone assessment
Tier 1		
VDP1 (Viking CD, DD, ED, GD and HD platforms) / LDP1 (Vampire VO/Valkyrie, Viscount VO and Vulcan VR platforms)	17.28	Value taken from the Habitats Regulations Assessment undertaken for the VDP1 and the LDP1 (BEIS, 2017). NOTE: All pipelines to remain *in situ* (Conoco Phillips, 2017a and 2017b).
Audrey A and B platforms and associated pipelines	11.68 km^2	Values taken from Centrica (2017).
Leman BH	Not quantified	Values for predicted temporary habitat loss are not presented in the Decommissioning Programme for this project (Shell UK Ltd., 2017).
Aggregate Area 484	1.38	8% of total licenced areas of 17.2 km^{2*}.
Total Tier 1	39.64 km^2	
Tier 2		
Application Area 483.	2.26	8% of total licenced areas of 28.2 km^{2*}.
Total Tier 2	41.91km^2	

* An average of 8% of the total licensed aggregate extraction areas is assumed to be dredged at any one time. This is based on the most recent (2016) Annual Report produced by the Crown Estate for the Humber region which reports that in 2016 dredging took place within approximately 8% of the total licensed area (Crown Estate, 2017).

5.9.2.3 Using the numbers assessed for temporary habitat loss/disturbance within the North Norfolk Sandbanks and Saturn Reef SAC during the construction phase of Hornsea Three (9.31 km^2) (Table 5.7) together with the values for Tier 1 and Tier 2 projects provided in Table 5.13, the total Tier 1 temporary habitat loss of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the SAC is predicted to be 39.64 km^2. This equates to 1.1% of the total area of this habitat within the site.

5.9.2.4 As measures will be implemented for Hornsea Three to ensure no direct impacts to Annex I reefs within the SAC, where possible, (see Table 4.5), no cumulative temporary loss of this habitat is predicted. The majority of the Tier 1 cumulative temporary habitat loss will arise from the Oil and Gas decommissioning activities (28.96 km^2), with the majority of this associated with over-trawlability surveys.

5.9.2.5 The potential for adverse effects arising from Hornsea Three in combination with VDP1 and LDP1 has already been assessed in the AA for these decommissioning projects (BEIS, 2017). Although the predicted area of physical impact arising from activities associated with Hornsea Three reported in BEIS (2017) is less than in this assessment, the proportion of the in-combination impact (based on the timing and plans and projects screened in to the VDP1 and LDP1 assessment) that is attributable to Hornsea Three, is relatively very small. Furthermore, once activities are completed no further on-going impacts will occur. The disturbance to the seabed is temporary and, following cessation of the activities that cause the physical impacts to the seabed, it is predicted that both the sandbank features and associated communities recovering within a relatively short period of time (BEIS, 2017). Consequently, there will not be an on-going in-combination adverse effect from physical impacts arising from these projects.

5.9.2.6 The Tier 1 projects which have the potential to physically overlap with construction activities within the Hornsea Three offshore cable corridor, and therefore potentially result in localised repeat disturbance, are aggregate extraction within licensed Area 484 (overlap with temporary working area only) and pipelines PL496 and PL497 (pipelines within the Audrey field which cross the Hornsea Three offshore cable corridor), although according Centrica (2017), these pipelines are to remain *in situ* following decommissioning of this field.The Tier 2 assessment, which also includes application Area 483, is predicted to result in up to 41.90 km^2 of temporary habitat loss. This application aggregate extraction area does not physically overlap with the offshore cable route corridor and therefore there is no potential for repeat disturbance to the same areas of seabed.

5.9.2.7 With respect to marine aggregate dredging, research has shown that the recovery of marine benthic communities to such activities appears to be largely site specific, reflecting complex interactions between the intensity of dredging and the level of screening, the composition of sediments at the site and the extent to which the resident organisms are adapted to environmental disturbance (Hill *et al.*, 2011). A relevant study in Licence Area 408 in the central North Sea has provided evidence that restoration of species composition and population density is accomplished rapidly by recolonisation of small individuals, even within the boundaries of the dredged area (Newell *et al.*, 2002).

5.9.2.8 A study investigating the effects of sustained dredging at the Cross Sands dredge site (5 to 25 km off the east coast of Great Yarmouth and Lowestoft), similarly demonstrated that even though variables such as abundance and species richness were found to depart significantly from an equitable state during the eight year study period, the effect did not persist from one year to the next and the potential for short-term partial recovery of the assemblage was not compromised (at least in terms of abundance and species richness) (Barrio Froján *et al.*, 2008).

5.9.2.9 The rapid restoration of community structure by active recolonisation of mobile, opportunistic species is characteristic of shallow marine environments. These environments are subject to the influences of tide and wave action, such as those associated with sandy sediments (i.e. similar to sandbanks but not Annex I habitats) within the Hornsea Three benthic ecology study area, and the species typically inhabiting them, such as polychaetes.

5.9.2.10 Both the Tier 1 and Tier 2 impacts are predicted to be of localised to discrete areas of the North Norfolk Sandbanks and Saturn Reef SAC, medium term duration (i.e. Hornsea Three construction phase of up to eight years over two phases, gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction), intermittent and reversible but with a relatively small amount of the loss described occurring at any one time.

Conclusion

5.9.2.11 Significant impacts are not anticipated to arise as a result of Hornsea Three in-combination with other plans and projects identified in Table 5.12, on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC, in relation to temporary habitat loss/disturbance. There is no indication that the effects of in-combination temporary habitat loss/disturbance would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats.

5.9.2.12 In relation to Tier 1 projects VDP1 and LDP1, the AA for these decommissioning actvities concluded that there would be no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC, in combination with Hornsea Three, as a result of temporary habitat loss.

5.9.2.13 Furthermore; there is no indication that this potential impact in-combination with other plans and projects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Temporary increases in suspended sediment

5.9.2.14 There is potential for impacts from increased SSC and associated sediment deposition to occur during the construction of Hornsea Three in-combination with aggregate extraction activities (Table 5.12).

5.9.2.15 All plans/projects/activities screened into the in-combination assessment of temporary increases in suspended sediment are on-going licensed and application aggregate extraction areas.

5.9.2.16 With respect to cumulative increased SSC and deposition within the North Norfolk Sandbanks and Saturn Reef SAC, only those in-combination projects with ZoIs that overlap the site boundary are considered relevant for this impact. These include:

- Tier 1 projects:
  - Licenced aggregate extraction areas: Area 484; and
  - Aggregation and extraction Application Area 506
- Tier 2 projects:
  - Aggregation and extraction Application Area 483.

5.9.2.17 The target material at these marine aggregate areas is sands and gravels. The aggregate deposits in this region are generally understood to contain <5% fines (silt and clay) and therefore the concentrations of this fraction in the overflow from the dredging vessels are anticipated to be relatively low. Aggregate extraction operations may release sediment into the water column through overspill and/or screening. The spatial extent of this plume will largely be determined by the sediments being extracted and the local hydrodynamic regime: heavier gravel-sized particles will settling rapidly at the discharge point, whilst sand-sized particles typically settle within about 250 m to 500 m, and within 5 km where tidal currents are strong (Environmental Statement volume 2, chapter 1: Marine Processes).

5.9.2.18 Plume dispersion modelling results for Areas 484 and 483 showed that the maximum extent of a turbid plume resulting from dredging activity would be 17.0 and 15.5 km, at 483 and 484, respectively (ABPmer, 2013). Maximum increases in near-seabed concentrations could exceed 600 mg/l in close proximity to the dredger within the application areas for a period of 1 hour, before reducing to approximately 50 to 150 mg/l for the remainder of the dredging period. It is expected that a return to near background concentrations would take approximately four days during spring tides or slightly longer during neap tides. The maximum sedimentation thickness resulting from the dredge plumes is expected to be approximately 1 mm in very close proximity to the dredge location, though the settled material will be transitory with the changing flood/ebb and spring/neap variations in the tidal currents (ABPmer, 2013). Deposition of dispersed sediment resulting from cable laying activities in Hornsea Three at aggregate dredging areas is considered to be low, as levels of deposition resulting from cable laying is predicted to be approximately 0.06 m within 100 m from the Hornsea Three offshore cable corridor (Environmental Statement volume 2, chapter 1: Marine Processes).

5.9.2.19 The turbid plume arising from the proposed dredging activities at Application Area 506 (see Figure 5.7) is predicted to extend between 2.5 to 4 km to the north-northwest and between 2 to 3 km to the south-southwest of the area (ABPmer, 2010). Depth averaged increases in SSC of between 50 and 70 mg/l above background levels would be likely to occur within the dredging area and in the streamline of a dredger at Area 506 (ABPmer, 2010). Outside of the dredging area SSC of 50 mg/l above background levels would be likely to occur. The plume was predicted to extend no further than 4 km north-northwest or 3 km south-southwest and at this point the predicted increase in suspended sediment was less than 10 mg/l. In terms of deposition the dredging footprint based on the Maximum design scenario was predicted to extend up to 2 km (ABPmer, 2010).

5.9.2.20 The plumes arising from both the aggregate extraction-related dredging activity and the Hornsea Three activities are generally predicted to coalesce together, creating a larger plume with concentrations similar to the alone activities, as opposed to an additive plume with a higher concentration (Environmental Statement volume 2, chapter 1: Marine Processes). It is considered that activities would mostly likely cause an additive plume of higher concentrations only if cable installation for Hornsea Three took place at the same time and in the vicinity of the western margin of 483 and eastern margin of 506 aggregate extraction areas, though this is predicted to cause a maximum additive plume of a few 10's mg/l over the construction of Hornsea Three alone, as described in (Environmental Statement volume 2, chapter 1: Marine Processes).

5.9.2.21 The impact of increased SSC and sediment deposition on Annex I sandbank and reef features of the North Norfolk Sandbanks and Saturn Reef SAC from dredging at aggregation extraction areas 483, 484 and 506 and activities relating to the development of Hornsea Three, is predicted to be of local spatial extent (i.e. within kilometres of Hornsea Three), of medium term (i.e. construction phase of up to eight years over two phases, gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction) intermittent in duration and reversible to baseline conditions following cessation of activities.

Conclusion

5.9.2.22 Significant impacts are not anticipated to arise as a result of Hornsea Three in-combination with other plans and projects identified in Table 5.12 on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC, in relation to temporary increases in suspended sediment. There is no indication that the effects of in-combination temporary increases in suspended sediment would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats.

5.9.2.23 Furthermore; there is no indication that this potential impact in-combination with other plans and projects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

5.9.3 Operation/maintenance

Permanent/long term habitat loss

5.9.3.1 Of the projects screened into the in-combination assessment only the Tier 1 Oil and Gas decommissioning projects (VDP1 and LDP1) and the Audrey platforms and pipelines are located within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC and so have the potential to result in cumulative permanent/long term habitat loss with Hornsea Three. There are no Tier 2 or Tier 3 plans/projects within the North Norfolk Sandbanks and Saturn Reef SAC that would contribute to in-combination permanent/long term habitat loss, as such there are no Tier 2 or 3 assessments for this impact.

Table 5.14: Predicted permanent habitat loss for Hornsea Three and other plans/projects/activities within the North Norfolk Sandbanks and Saturn Reef SAC screened in for in-combination assessment.

Project	Total predicted permanent/long term habitat loss (km^2)	Source
Oil and Gas Decommissioning		
VDP1 (Viking CD, DD, ED, GD and HD platforms) / LDP1 (Vampire VO/Valkyrie, Viscount VO and Vulcan VR platforms)	0.049	Value taken from the Habitats Regulations Assessment undertaken for the VDP1 and the LDP1 (BEIS, 2017). All pipelines will remain *in situ* post decommissioning, but are buried so do not represent long term/permanent habitat loss (Conoco Phillips, 2017a and 2017b).
Audrey A and B platforms and associated pipelines	0.081 km^2	Values taken from Centrica (2017).
Total Oil and Gas	0.13 km^2	

5.9.3.2 The total predicted in-combination permanent/long term habitat loss of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC as a result of Hornsea Three and Oil and Gas decommissioning is up to 0.63 km^2 (i.e. 0.5 + 0.13 km^2). This equates to 0.02% of the total area of this habitat within the site (i.e. all Annex I sandbank habitat). As measures will be implemented for Hornsea Three to avoid direct impacts to Annex I reefs where possible, within the North Norfolk Sandbanks and Saturn Reef SAC (see Table 4.5), there is no predicted in-combination permanent/long term loss of this habitats.

5.9.3.3 The potential for adverse effects arising from Hornsea Three in combination with VDP1 and LDP1 has already been assessed in the AA for these decommissioning projects (BEIS, 2017). The predicted area of physical loss of habitat from activities associated with Hornsea Three reported in BEIS (2017) is a relatively very small proportion of the in-combination impact (based on the timing and plans and projects screened in to the VDP1 and LDP1 assessment). This assessment concludes that there will not be an ongoing, in-combination adverse effect from physical loss arising from these projects. In addition, the total amount of predicted habitat loss from cable protection and crossings has reduced significantly (more than 50%) since PEIR, on which the assessment in BEIS (2017) is based. The assessment concludes that the predicated amount of permanent loss of habitat will be localised and is a very small proportion of the total Annex 1 habitat within the site. Furthermore, the physical presence will not cause significant changes to the hydrodynamic regime that maintains the sandbank features as these are influenced by large scale coriolis forces and tidal currents (Collins et al. 1995, ABPmer 2005). There will be localised changes in the biological communities in areas where the substrate has changed but these will not affect the overall community structure within the SAC (BEIS, 2017). Consequently, there will not be an ongoing, in-combination adverse effect from physical impacts arising from these projects.

5.9.3.4 All of the permanent/long term loss outlined above has the potential to be permanent/long term on the basis that the rock placement installed during decommissioning is part of the decommissioning process and would not be subsequently removed and the assessment for Hornsea Three also assumes that, as a maximum design scenario, cable protection may be left in situ after decommissioning. It should be noted, however, that the Habitats Regulations Assessment for the VDP1 and LDP1 predicts that a proportion of the rock placed on the seabed will be buried and will therefore not cause on going long-term loss of habitat (BEIS, 2017). The impact of in-combination permanent/long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the SAC, affecting a small proportion of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC.

Conclusion

5.9.3.5 Significant impacts are not anticipated to arise as a result of Hornsea Three in-combination with other plans and projects identified in Table 5.12 on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC, in relation to permanent/long term habitat loss. There is no indication that the effects of in-combination permanent/long term habitat loss would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats.

5.9.3.6 In relation to Tier 1 projects VDP1 and LDP1, the AA for these decommissioning actvities concluded that there would be no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC, in combination with Hornsea Three, as result of permanent/long term habitat loss.

5.9.3.7 Furthermore; there is no indication that this potential impact in-combination with other plans and projects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

Changes to physical processes

Wave regime

5.9.3.8 With respect to effects on offshore sandbanks in the North Norfolk Sandbanks and Saturn Reef SAC, the closest sandbanks to the Hornsea Three array area are the Indefatigable Banks which are located approximately 10 km to the southwest of the Hornsea Three array area. Owing to the (east – west) alignment of the Hornsea Three array area relative to Hornsea Project One and Hornsea Project Two, there is very limited potential for a cumulative reduction in wave energy at these nearby banks. Moreover, as the Indefatigable Banks are understood to be largely relict features, it is extremely unlikely that any reductions in wave activity over the bank crests would result in a corresponding morphological change. Predicted impacts along the Hornsea Three offshore cable corridor will be similar to the Hornsea Three array, but of a significantly reduced extent. As such, there is very limited potential for a cumulative reduction in wave energy at sandbanks which are slightly covered by water all the time with the North Norfolk Sandbanks and Saturn Reef SAC.

Conclusion

5.9.3.9 Significant impacts are not anticipated to arise as a result of Hornsea Three in-combination with other plans and projects identified in Table 5.12 on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SAC, in relation to changes in physical processes. There is no indication that the effects of in-combination changes in physical processes would adversely affect the environmental quality, natural environmental processes and extent of sandbanks which are slightly covered by seawater all the time or reef habitats.

5.9.3.10 Furthermore; there is no indication that this potential impact in-combination with other plans and projects would lead to an adverse change to the physical structure, diversity, community structure or typical species that are representative of sandbanks which are slightly covered by seawater all the time or reef habitats. Therefore, no adverse effect on the integrity of the North Norfolk Sandbanks and Saturn Reef SAC from this potential impact is concluded.

5.10 Summary

5.10.1.1 The screening process indicated that LSE on the interest features of the subtidal North Norfolk Sandbanks and Saturn Reef SAC and The Wash and North Norfolk Coast SAC could not be discounted and so a systematic assessment of the potential for an adverse effect on the integrity of these sites has been undertaken.

5.10.1.2 The assessment has considered the potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects with respect to the site's Conservation Objectives.

5.10.1.3 With respect to the Conservation Objectives, there is no indication, that Hornsea Three, alone or in-combination with other plans and projects would prevent the favourable condition of the Annex I habitats for which The Wash and North Norfolk Coast SAC is designated, being maintained. On this basis, there is no indication of an adverse effect on integrity on The Wash and North Norfolk Coast SAC.

5.10.1.4 With respect to the Conservation Objectives, there is no indication, , that Hornsea Three, alone or in-combination with other plans and projects would prevent the restoration of favourable condition for the Annex I habitats for which the North Norfolk Sandbanks and Saturn Reef SAC is designated. On this basis, there is no indication of an adverse effect on integrity on the North Norfolk Sandbanks and Saturn Reef SAC.

5.10.1.5 These conclusions are summarised in Table 5.15 below.

Table 5.15: Summary of conclusions of Adverse Effects on I ntegrity alone and in-combination with other plans and projects.

Site	Feature	Project phase	Potential Impact	Conclusion Project alone	Conclusion project in-combination with other plans and projects
The Wash and North Norfolk Coast SAC	Sandbanks which are slightly covered by seawater all the time Reefs	Construction/ Decommissioning	Temporary habitat loss/disturbance	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Temporary increases in suspended and sediments/smothering	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Accidental pollution.	No adverse effect on site integrity predicted	No adverse effect on site integrity
		Operation/ Maintenance	Long-term habitat loss	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Colonisation of hard structures	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Changes in physical processes	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Temporary seabed disturbance	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Accidental pollution	No adverse effect on site integrity predicted	No adverse effect on site integrity
North Norfolk Sandbanks and Saturn Reef SAC	Sandbanks which are slightly covered by seawater all the time Reefs	Construction/ Decommissioning	Temporary habitat loss/disturbance	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Temporary increases in suspended and sediments/smothering	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Accidental pollution.	No adverse effect on site integrity predicted	No adverse effect on site integrity
		Operation/ Maintenance	Long-term habitat loss	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Colonisation of hard structures	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Changes in physical processes	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Temporary seabed disturbance	No adverse effect on site integrity predicted	No adverse effect on site integrity
			Accidental pollution	No adverse effect on site integrity predicted	No adverse effect on site integrity

6. Assessment of Adverse Effects on Integrity: Annex II species - marine mammals

6.1 Introduction

6.1.1.1 The screening exercise (Stage 1 of the HRA process) and subsequent evaluation in Section 3.4, identified potential for LSEs on marine mammal features of the sites listed in Table 6.1 and shown in Figure 6.1.

6.2 Conservation Objectives

6.2.1.1 The overarching Conservation Objectives (COs) of UK European sites are detailed below (Natural England, 2014a):

Avoid the deterioration of the qualifying natural habitats and the habitats of qualifying species, and the significant disturbance of those qualifying species, ensuring the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features; and

Subject to natural change, to maintain or restore:

- *The extent and distribution of qualifying natural habitats and habitats of qualifying species;*
- *The structure and function (including typical species) of qualifying natural habitats and 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.*

6.2.1.2 The Conservation Objectives are focused on addressing pressures that may affect the designated sites integrity. The critical point about the site integrity is not the extent or degree of impact resulting from a pressure, but the potential to affect (alone or in-combination) the ability of the site to meet the Conservation Objectives and maintain the existing Favourable Conservation Status (FCS) of the species.

6.2.1.3 The Conservation Objectives specifically for each site and associated marine mammal qualifying feature, screened in for assessment (Table 6.1) are outlined below. Where available the Natural England supplementary advice had be used to refine the Conservation Objectives for each site.

6.2.2 The Wash and North Norfolk Coast SAC:

6.2.2.1 Ensure that the integrity of the site is maintained, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining;

- The extent and distribution of 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

6.2.3 Humber Estuary SAC/Ramsar:

6.2.3.1 Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;

- The extent and distribution of 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.

NB: Supplementary advice is not currently available for this site, however it is noted within the Humber Management Scheme fact sheet on grey seal that this feature is in favourable condition. Therefore this assessment has assumed that the Conservation Objectives are to maintain this status.

6.2.4 Berwickshire and North Northumberland Coast SAC:

6.2.4.1 Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving Favourable Conservation Status of its Qualifying Features, by maintaining or restoring;

- The extent and distribution of 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.

6.2.5 Southern North Sea cSAC:

6.2.5.1 To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status (FCS) for the UK harbour porpoise. To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:

- The species is a viable component of the site;
- There is no significant disturbance of the species; and
- The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

6.2.6 Klaverbank SCI Conservation Objectives:

6.2.6.1 Harbour seal and grey seal:

- Maintain the distribution, extent and quality of habitat for the purpose of maintaining the population (Jak *et al*., 2009).

6.2.6.2 Harbour porpoise:

- Maintain the extent and quality of habitat in order to maintain the population.

NB: To date, surveys of Klaverbank indicate no special significance as a reproduction site, foraging site or otherwise, compared to other parts of the Dutch sector of the North Sea. (Jak *et al*., 2009).

6.2.7 Doggersbank SCI Conservation Objectives:

6.2.7.1 Maintenance at favourable conservation status of the qualifying species (harbour porpoise, harbour seal and common seal) and their natural habitats.

6.2.8 Noordzeekustzone SAC/ Noordzeekustzone II SCI Conservation Objectives:

6.2.8.1 Maintain the extent and quality of habitat in order to maintain the population (grey seal).

6.3 Potential impacts

6.3.1.1 The potential effects on marine mammal features for each potential impact screened into the assessment (Table 6.1) have been described in the Environmental Statement volume 2, chapter 4: Marine Mammals and are summarised below (Table 6.2).

6.3.1.2 At the screening stage of this HRA, it was concluded that there would be no potential LSE on marine mammal features as a result of indirect effects on prey species. Therefore, the structure, function, distribution, extent and quality of habitat will be maintained, in order to maintain each designated population, as defined in the Conservation Objectives for each site. Subsequently, no further significant effects on benthic ecology and fish and shellfish have been identified. Therefore, this has not been taken through to the assessment stage of this HRA.

Table 6.1: European sites and features for which potential for LSE cannot be discounted – marine mammals.

Site	Feature	Project phase	Potential impact
The Wash and North Norfolk Coast SAC	• Harbour seal	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events
Doggersbank SCI (Dutch designation)	• Harbour seal • Grey seal	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events
Klaverbank SCI	• Harbour seal • Grey seal • Harbour porpoise	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events
Humber Estuary SAC/Ramsar	• Grey seal	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events
Noordzeekustzone SAC/ Noordzeekustzone II SCI	• Grey seal	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events
Berwickshire and North Northumberland Coast SAC	• Grey seal	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events
Southern North Sea cSAC	• Harbour porpoise	Construction/Decommissioning	• Underwater noise from foundation installation and UXO clearance (construction) • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events

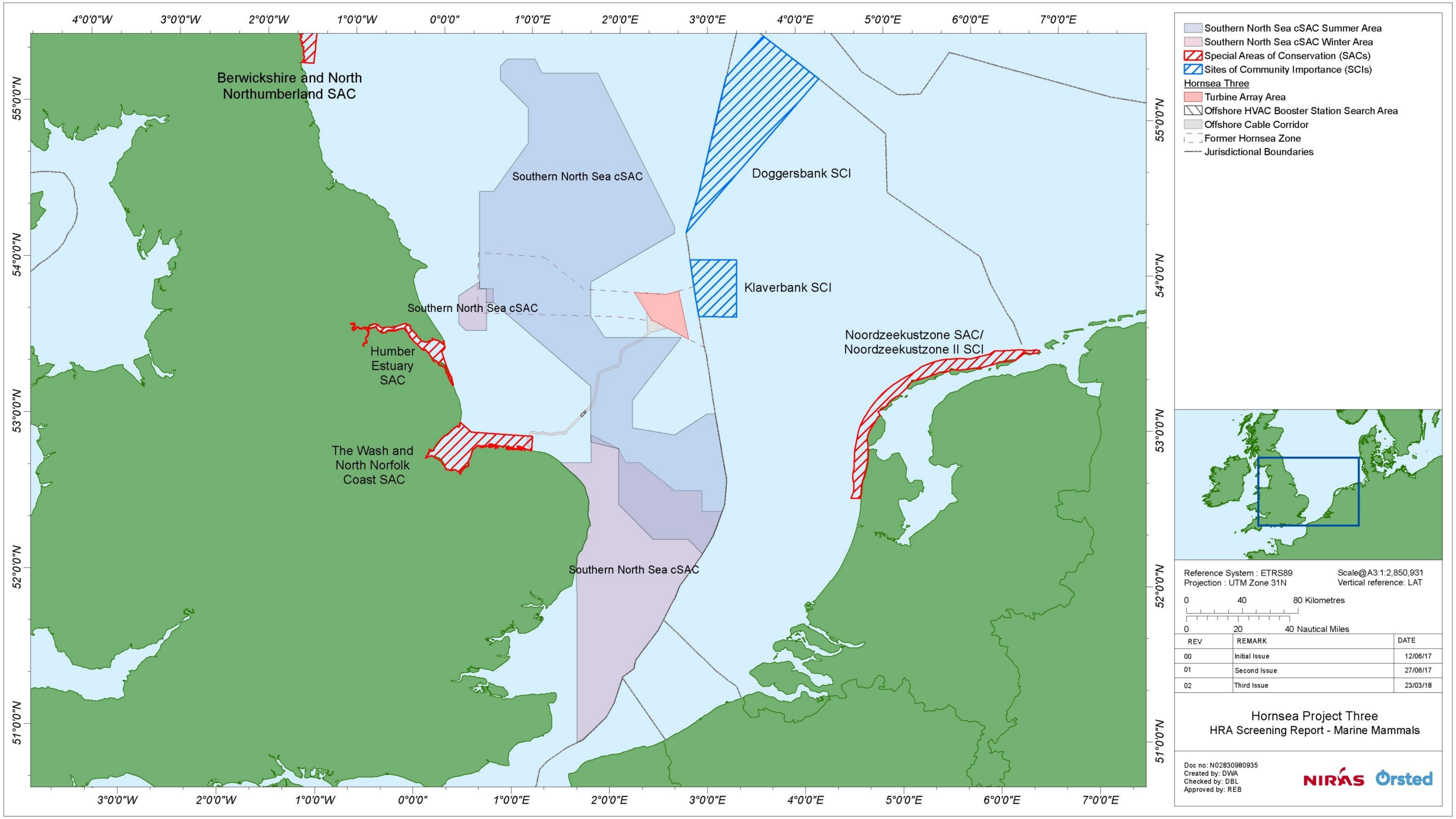


Figure 6.1: European sites designated for Annex II marine mammals identified for further assessment.

Table 6.2: Potential Impacts from Hornsea Three on marine mammal site features.

Project phase	Potential Impact	Justification
Construction	Underwater noise	There is the potential for underwater noise arising from foundation piling and other construction activities including pre construction UXO clearance within the Hornsea Three array and offshore cable corridor area to cause physical/auditory injury or disturbance to marine mammals.
	Increased vessel traffic	Increased vessel traffic during construction may result in an increase in noise disturbance to marine mammals. Increased vessel traffic during construction may result in an increased collision risk to marine mammals.
	Accidental pollution	There is a risk of pollution being accidentally released from sources including construction and installation vessels/vehicles, machinery and offshore fuel storage tanks and from the construction process itself. The release of such contaminants may lead to impacts on marine mammals.
Operation/maintenance	Increased vessel traffic	Increased vessel traffic during operation and maintenance may result in an increase in noise disturbance to marine mammals. Increased vessel traffic during operation and maintenance may result in an increased collision risk to marine mammals.
	Accidental pollution	There is a risk of pollution being accidentally released from vessels, vehicles, machinery and offshore fuel storage tanks during the operation and maintenance phase as well as from the turbines and offshore substations themselves. The release of such contaminants may lead to impacts on the marine mammals.
Decommissioning	Impacts are assumed to be similar or reduced from those predicted during the construction phase	

6.4 Baseline information

6.4.1.1 Baseline information on the Annex II marine mammals features requiring further assessment was gathered through a combination of desktop studies and the results of site specific surveys carried out as part of marine mammals characterisation, presented in full in the Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report.

6.4.2 Study area

6.4.2.1 For the purposes of the marine mammal assessment, the study area (illustrated in Figure 6.2) was defined in two ways:

- Hornsea Three marine mammal study area – this study area encompasses the Hornsea Three array area and offshore cable corridor (including the temporary working areas). The area extends out to the former Hornsea Zone plus a 10 km buffer around its perimeter. Site-specific field surveys (boat-based and aerial) were collected over survey extents within the Hornsea Three marine mammal study area agreed with statutory consultees (EWG meeting in April 2016 and full meeting minutes are presented in the Evidence Plan (Consultation Report, Annex 1 Evidence Plan) and supplemented with data gathered through an extensive literature review. This area provides a suitable baseline against which to assess potential impacts from Hornsea Three as it encompasses the majority of the zone of potential ecological impact (ZoI); and
- Regional marine mammal study area – this area is represented largely by SCANS (Small Cetaceans Abundance in the North Sea) III Block O as the central point of focus, and extends further east and south to ensure that all key areas within the southern North Sea are encompassed (Figure 6.2). The regional marine mammal study area provides a wider geographic context for comparison with Hornsea Three data in terms of the species present and their estimated densities and abundance; and
- Sites designated for the conservation of marine mammal features within this region provide a useful context for understanding the relative importance of marine mammal species found within the southern North Sea, and consequently within the Hornsea Three marine mammal study area. The most useful population-level information was referenced to the Management Units (MUs) for each of the qualifying features assessed (Figure 6.3 and Figure 6.5).

Management Units

6.4.2.2 In addition to information collected through survey work, in order to provide context for assessing marine mammals populations in relation to Hornsea Three, the literature review presented in Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report provides information on marine mammal populations in a wider geographic frame of reference.

6.4.2.3 For marine mammals, this can be difficult to determine due to their wide-ranging nature. The starting point for considering marine mammals in a wider context was to look at the areas delineated as Management Units (MU) for each species by the statutory authorities. MUs are transboundary zones; the UK specific population of a species if required can be calculated based on the area of the Exclusive Economic Zone (EEZ). A recent guidance report prepared by the UK SNCBs, together forming the Inter-Agency Marine Mammal Working Group (IAMMWG), has recommended MUs for the most common species of marine mammals in the UK (IAMMWG, 2013) with a supplementary report provided in 2015 providing revised cetacean MUs (IAMMWG, 2015).

6.4.2.4 For each MU for each marine mammal, IAMMWG recommend reference populations (abundance and geographic area) against which to measure potential effects of development and these are presented in the individual species accounts below.

6.4.2.5 All sites screened in for assessment within this RIAA are located with the same North Sea MU(s) (see Figure 6.3 and Figure 6.5). Furthermore, the approach agreed with the EWG and described in the JNCC Workshop Report (2016), is that it is not, currently, appropriate or practical to maintain a given marine mammal abundance within a site because of the natural variability in numbers. Consequently, as long as the abundance of a species within the MU is maintained and any site-specific Conservation Objectives are met, FCS of the species will be maintained for a site.

6.4.2.6 The approach taken in this assessment, therefore, is to present the technical analyses that underpin the assessments for each site (these will be common to each site as they all lie within the same MU). The outcomes of these analyses are then applied to the assessment of each site and associated qualifying marine mammal features described in Table 6.1 in turn.

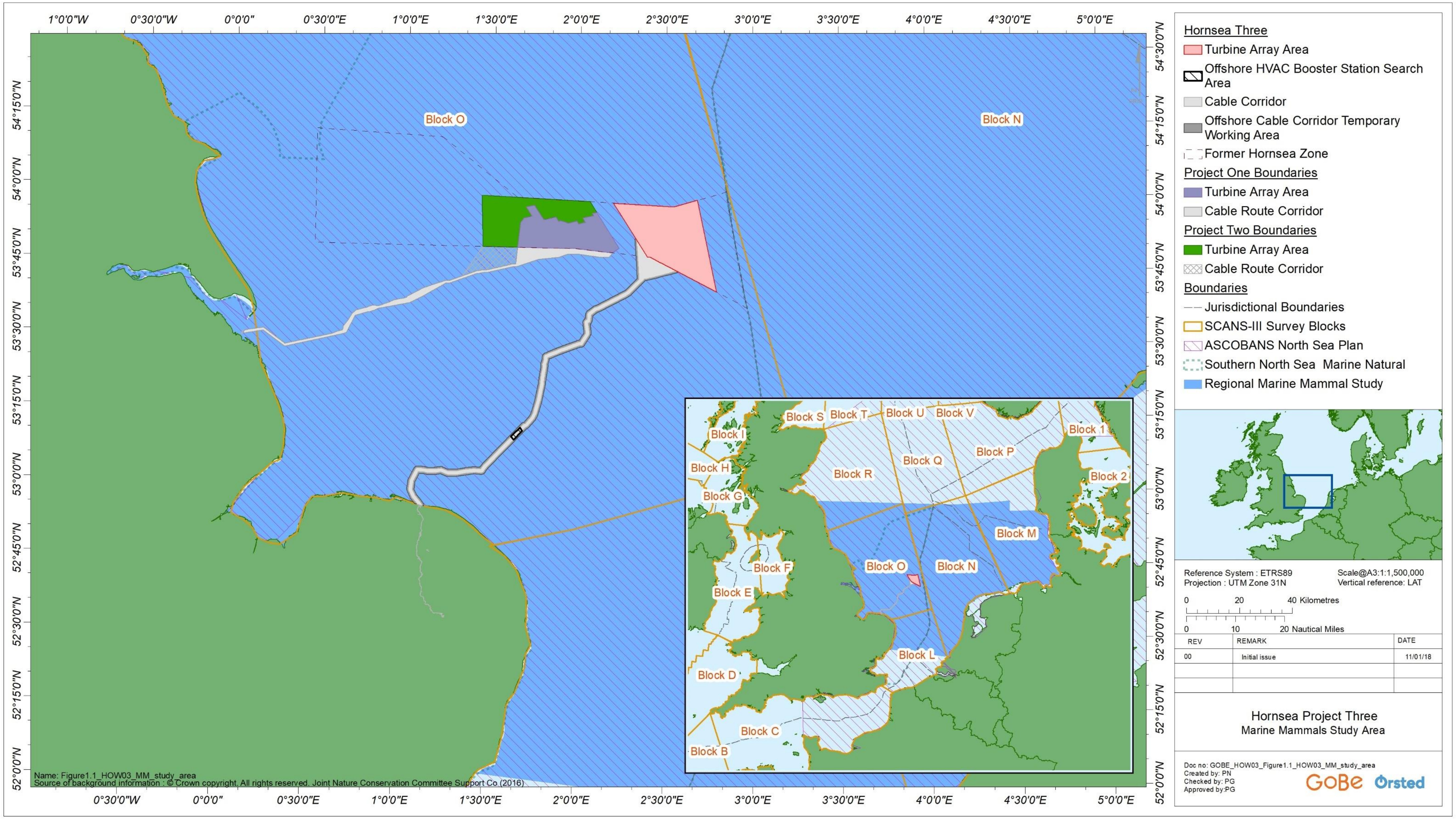


Figure 6.2: Location of the Hornsea Three marine mammal study area (within which is the Hornsea Three array area and offshore cable route corridor and the former Hornsea Zone) and location of the regional marine mammal study area.

6.4.3 Methodology to inform baseline

6.4.3.1 The methodology to inform the baseline was discussed and agreed as part of the Evidence Plan process (Consultation Report, Annex 1 Evidence Plan).

6.4.3.2 The approach involved the use of existing site-specific, boat-based survey data gathered across the former Hornsea Zone plus a 10 km buffer ('Hornsea Zone study area') and re-analysed for the Hornsea Three array area, together with the use of additional site-specific aerial survey data from ongoing surveys across the Hornsea Three array area plus a 4 km buffer ('Hornsea Three study area'). In addition, data were gathered through an extensive literature review of existing data sources.

6.4.4 Desktop study

6.4.4.1 Information on marine mammals within the regional marine mammal study area was collected through a detailed desktop review of existing studies and datasets (Table 6.3). A full review is provided in Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report.

6.4.5 Site specific surveys

6.4.5.1 To inform the EIA and RIAA, marine mammal surveys were undertaken, as agreed with the Marine Mammal EWG. A summary of the surveys undertaken to date is outlined in Table 6.4 below.

Data limitations

6.4.5.2 Marine mammals are mobile species and exhibit varying patterns of spatial and temporal distribution. All field surveys, including aerial surveys for Hornsea Three and previous aerial and boat based surveys relating to the former Hornsea Zone, were undertaken on a monthly basis to capture some of the variation in marine mammal distribution across the study area over time. It should be noted, however, that the data collected during these boat-based and aerial surveys represent snapshots of the marine mammals at the time of sampling and that abundance and distribution of marine mammal species is likely to vary both seasonally and annually.

6.4.5.3 A detailed review of the assumptions and limitations of the boat based and aerial surveys is provided in Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report.

6.4.5.4 The site-specific surveys (among other matters) have been discussed with regulators and statutory and non-statutory consultees through the marine mammal Expert Working Group (EWG) as part of the Evidence Plan process. The approach to data collection, including the use of field survey data from across the former Hornsea Zone (gathered for Hornsea Project One and Hornsea Project Two), and specific to Hornsea Three, was agreed during EWG consultation.

Table 6.3: Summary of existing data sources for marine mammals.

Title	Source	Year	Author
Atlas of cetacean distribution in north west European waters	JNCC	2003	Reid *et al.*
UK Cetacean Status Review	Sea Watch Foundation	2003	Evans *et al.*
Abundance of Harbour Porpoise and other Cetaceans in the North Sea and Adjacent Waters	SCANS I	2002	Hammond *et al.*
Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management	SCANS II	2006	Hammond
Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys	SCANS III	2017	Hammond *et al.*
Cetacean and pinniped data for Norfolk and Lincolnshire coast	Wildfowl and Wetland Trust aerial surveys	2009	WWT Consulting Ltd
Seal data for Horsey	Friends of Horsey Seals (FoHS)	2017	Rothney E.
Seal data for Blakeney	National Trust	2017	N/A
Regional biodiversity records for marine mammals	Lincolnshire Environmental Records Centre	1997 to 2017	N/A
Regional biodiversity records for marine mammals	Norfolk Environmental Records Centre	1997 to 2017	N/A
Scientific Advice on Matters Related to the Management of Seal Populations	Special Committee on Seals (SCOS)	2011, 2012, 2013, 2014, 2015, 2016, 2017	SCOS
Telemetry data for grey and harbour seals tagged along the Norfolk and Lincolnshire coastlines	SMRU	1988 to 2015	Plunkett (2017) (appendix A of Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report)
Updated Grey Seal Usage Maps in the North Sea	Department of Energy and Climate Change (DECC)	2016	Jones and Russell
Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources	JNCC	2016	Paxton *et al.*
Management Units for Cetaceans in UK Waters	JNCC	2015	Inter-Agency Marine Mammal Working Group (IAMMWG)
Management Units for Marine Mammals in UK Waters	JNCC	2013	IAMMWG
Monthly boat-based marine mammal sightings along ferry routes	Marine Life	2010 to 2016	Marine Life (2017)

Table 6.4: Summary of Hornsea marine mammal survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Year	Reference to further information
Hornsea Three aerial surveys	Hornsea Three study area	Survey commissioned specifically for Hornsea Three. Monthly aerial surveys of marine mammals (and seabirds) along transects spaced approximately 2.5 km apart over the survey area (Figure 2.3 in Environment Statement annex 4.1: Marine Mammal Technical Report). Surveys were carried out from April 2016 until November 2017 inclusive. Aerial surveys were carried out using high resolution digital video cameras each month to record the abundance of each marine mammal species within the survey strip. The data were subsequently processed in the laboratory with identification carried out to species level where possible. As agreed at the EWG meeting in April 2016, only 10% of the data was analysed as this was confirmed to be sufficient to provide an estimate of densities for harbour porpoise and full meeting minutes are presented within the Evidence Plan (Consultation Report, Annex 1 Evidence Plan). Quality assurance was carried out on a 20% sample to validate the results. Data were analysed for harbour porpoise to produce surface-density estimates across the survey area. It was not possible to do the same for other species due to the low numbers recorded during the surveys. As no site-specific correction factor could be applied to the aerial data to estimate absolute abundance/density of harbour porpoise, it was agreed with the EWG that a published value from Teilmann *et al.* (2013) could be applied (see section 2.5.2 in Environment Statement annex 4.1: Marine Mammal Technical Report)	HiDef	2016 to 2017	Environmental Statement volume 5, annex 4.1 Marine Mammal Technical Report
Hornsea boat based surveys	Former Hornsea Zone study area	Survey commissioned for the former Hornsea Zone and re-analysed for the Hornsea Three array area. Monthly boat based visual and acoustic surveys across the survey area were undertaken over a 36 month period between March 2010 and February 2013. Transects were spaced 6 km apart across the former Hornsea Zone study area with additional survey effort (2 km spaced transects) across the Hornsea Project One and Hornsea Project Two array areas plus 4 km buffers) (Figure 2.1 in annex 4.1: Marine Mammal Technical Report). Visual surveys were conducted following an adaptation of the European Seabirds at Sea (Environmental StatementAS) methodology and using the Distance sampling technique. Surveys were conducted in sea state 3 or less and the resulting data were corrected for the effects of sea state on detection probability. Acoustic surveys were conducted at the same time from the survey vessel using a towed hydrophone system with a similar set up as employed during the SCANS surveys. Data were acquired using PAMGUARD which uses click detector software to identify the marine mammal species. The data were analysed to determine the abundance and density of marine mammal species across the survey area, using environmental data to model densities across areas not covered by the transects. Where possible the absolute (rather than relative) abundance of a marine mammal species was estimated.	EMU	2010 to 2013	Environmental Statement Volume 5, annex 4.1: Marine Mammal Technical Report

6.4.6 Species accounts

6.4.6.1 Information on the reference populations used for the purposes of the RIAA and a summary of the ecology of each Annex II marine mammals feature relevant to this assessment is provided in the sections below.

Harbour porpoise

6.4.6.2 Harbour porpoise are widespread throughout the temperate waters of the North Atlantic and North Pacific and are the most abundant cetacean in UK waters, with the whole of the coastline of the North Sea considered an important area for this species (Reid *et al.,* 2003).

6.4.6.3 Visual and acoustic sightings data from surveys of the former Hornsea Zone plus 10 km show that harbour porpoises are widely distributed across the Hornsea Three marine mammal study area (see Environmental Statement volume 2, chapter 4: Marine Mammals Figure 4.3). Similarly, historical sightings data (mainly land-based) from Greater Lincolnshire Nature Partnership (GLNP) confirmed that harbour porpoise is commonly sighted along coastal waters.

6.4.6.4 Harbour porpoise density and abundance data derived from boat-based visual and acoustic surveys of the former Hornsea Zone study area and from aerial surveys of the Hornsea Three study area are summarised in Table 6.5 below. Comparison of the densities using either the boat-based visual or boat-based acoustic shows that densities are similar in both survey extents, suggesting that the Hornsea Three study area is not an area of particular importance within the former Hornsea Zone study area (Table 6.5). While each of the survey methods were generally similar between the two survey areas, there was high variation in the density estimates calculated from the different surveys. The aerial surveys provided the lowest estimate of abundance, with the acoustic surveys giving the highest estimate.

Table 6.5: Summary of abundance and density estimates of harbour porpoise across the different survey areas and based on three datasets: boat-based visual, boat-based acoustic and aerial video.

Data source	Area (km^2)	Density (individuals per km^2)	Abundance
Former Hornsea Zone study area			
Visual boat-based	9,276	1.72	15,955
Acoustic boat-based	9,276	2.22	20,593
Hornsea Three study area			
Visual boat-based	1,230	1.76	165
Acoustic boat-based	1,230	2.87	3,530
Aerial video	1,230	0.912	1,122

6.4.6.5 In comparison to the regional marine mammal study area these figures suggest that the Hornsea Three marine mammal study area (Hornsea Zone plus Hornsea Three cable route plus appropriate buffers) is of relatively high importance for harbour porpoise since the densities are higher than the average density of 0.888 animals km^{-2} (CV = 0.21, mean group size 1.31) recorded for SCANS III block O in the south central North Sea (Hammond *et al.*, 2013). This conclusion is also supported by the modelled surface density maps for SCANS-II (Hammond *et al.*, 2013) which reported the highest densities in the whole of the North Sea in an area overlapping the former Hornsea Zone. In this relatively high density region, more than 1.2 animals km^{-2} are predicted (Hammond *et al.*, 2013).

6.4.6.6 The IAMMWG has identified three MUs as appropriate for harbour porpoise: North Sea (NS), West Scotland (WS) and Celtic and Irish Seas (CIS). Hornsea Three array and offshore cable corridor falls within the North Sea MU which extends from the southeast coast of England up to the northern tip of Scotland and comprising the ICES areas IV, VIId and Division IIIa (Figure 6.3). The total harbour porpoise abundance for the North Sea MU was estimated as 227,298 animals (IAMMWG, 2015). The abundance of harbour porpoise within UK waters of the overall NS MU is 110,433 (95% Confidence Internal (CI) - 80,866 to 150,811) (IAMMWG, 2015). This was updated following SCANS III surveys to a total of 345,373 (95% confidence interval 246,626 to 496,752) (Hammond *et al.,* 2017). Where a quantitative assessment of impact is possible, the MU abundance estimate has been used as the reference population against which to assess potential impact.

6.4.6.7 Table 6.6 summarises the designated sites within the North Sea MU with harbour porpoise listed as a qualifying interest feature which have been brought forward for further assessment because LSE cannot be discounted.

Table 6.6: European sites with harbour porpoise as a qualifying interest feature brought forward for further assessment.

Site Name	Distance from Hornsea Three array area or offshore cable route (km)	Potential Effect
Southern North Sea cSAC	0 (Hornsea Three offshore cable corridor)	• Underwater noise from foundation installation and UXO clearance (pre construction/construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Klaverbank SCI	11 (Hornsea Three array area)	• Underwater noise from foundation installation and UXO clearance (pre construction/construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)

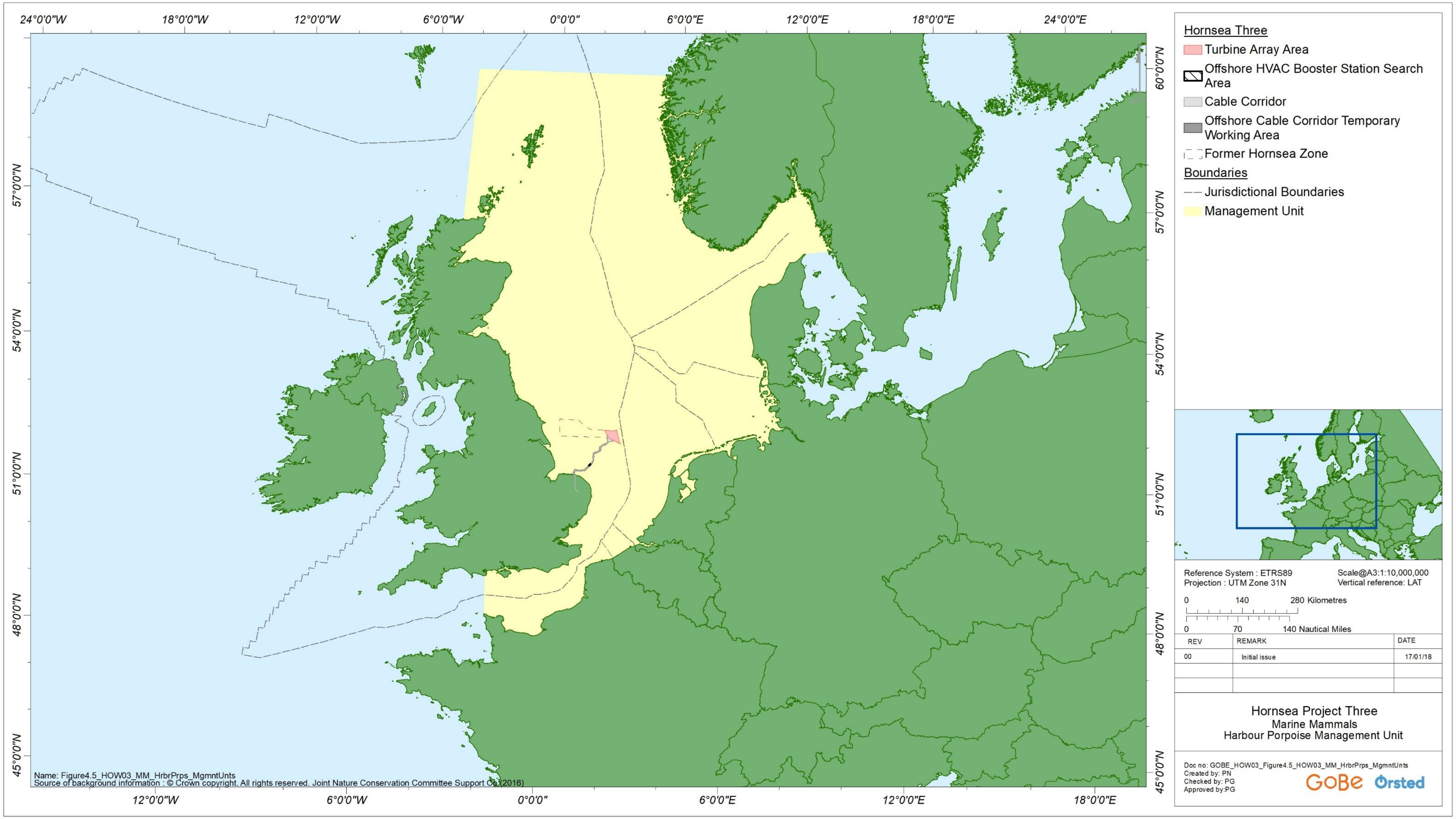


Figure 6.3: Harbour porpoise Management Unit.

Grey Seal

6.4.6.8 In the south central North Sea grey seal breed on the sandbanks at Donna Nook, Blakeney Point and Scroby Sands between September and December and are also known to haul-out at sites in the Wash.

6.4.6.9 During boat-based surveys across the former Hornsea Zone study area, a total of 247 grey seals were recorded. There was a notable decrease in recorded animals between September and December which coincides with the main haul-out period. Abundance of grey seal within the former Hornsea Zone study area has been calculated as 372 individuals.

6.4.6.10 Grey seal at sea usage data provided by SMRU (Russell *et al.*, 2017) confirm that grey seal is present throughout the Hornsea Three array area and offshore cable corridor, with at-sea usage highest in the southwest near to the Donna Nook haul-out site and The Wash (Figure 6.4). The average density for the former Hornsea Zone study area estimated from the SMRU at-sea data was 1.47 animals km^{-2} compared with 0.04 animals km^{-2} estimated using boat-based data from surveys across the former Hornsea Zone study area.

6.4.6.11 Female grey seals store fat reserves prior to lactation to allow reduced foraging during lactation. Grey seals are therefore particularly vulnerable to disturbance when building up fat reserves.

6.4.6.12 Breeding locations tend to be in remote locations; however, the colony at Donna Nook on the Lincolnshire coastline to the north of the Hornsea Three offshore cable corridor is an exception to this (SMRU, 2011).

6.4.6.13 While grey seals are known to travel up to 2,100 km on foraging trips, most foraging trips remain within 145 km from haul out sites (SCOS, 2015). SMRU telemetry data show animals crossing the Hornsea Three marine mammal study area (SMRU, 2017) (Figure 4.26 of Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report), and these are considered likely to be foraging animals.

6.4.6.14 Hornsea Three falls within the South East England MU, however, tagging studies have demonstrated that seals hauling out in the North East England MU also travel through the Hornsea Three study area. Therefore the Hornsea Three HRA for grey seal should be carried out against the South East England MU and the North East England MU combined (Figure 6.5) with combined associated abundance estimate. The combined population size for these two MUs has been estimated as 40,040 (Environmental Statement volume 5, annex 4.1: Marine Mammals Technical Report Section 4.5.5).

6.4.6.15 Table 6.7 summarises the designated sites within normal (<145 km) foraging range of Hornsea Three which have grey seal listed as a qualifying interest feature. Sites designated for grey seal that lie within the normal foraging range of this species from Hornsea Three (SMRU, 2017) have been considered to inform the RIAA (Annex 1: HRA Screening Report).

Table 6.7: European sites with grey seal as a qualifying interest feature brought forward for further assessment.

Site Name	Distance from Hornsea Three array area and/or offshore cable corridor (km)	Potential impact
Klaverbank SCI	11	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Dogger Bank SCI (Dutch)	42	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Humber Estuary SAC/Ramsar	74	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Noordzeekustzone SAC/ Noordzeekustzone II SCI	138	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Berwickshire and North Northumberland Coast SAC	266	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)

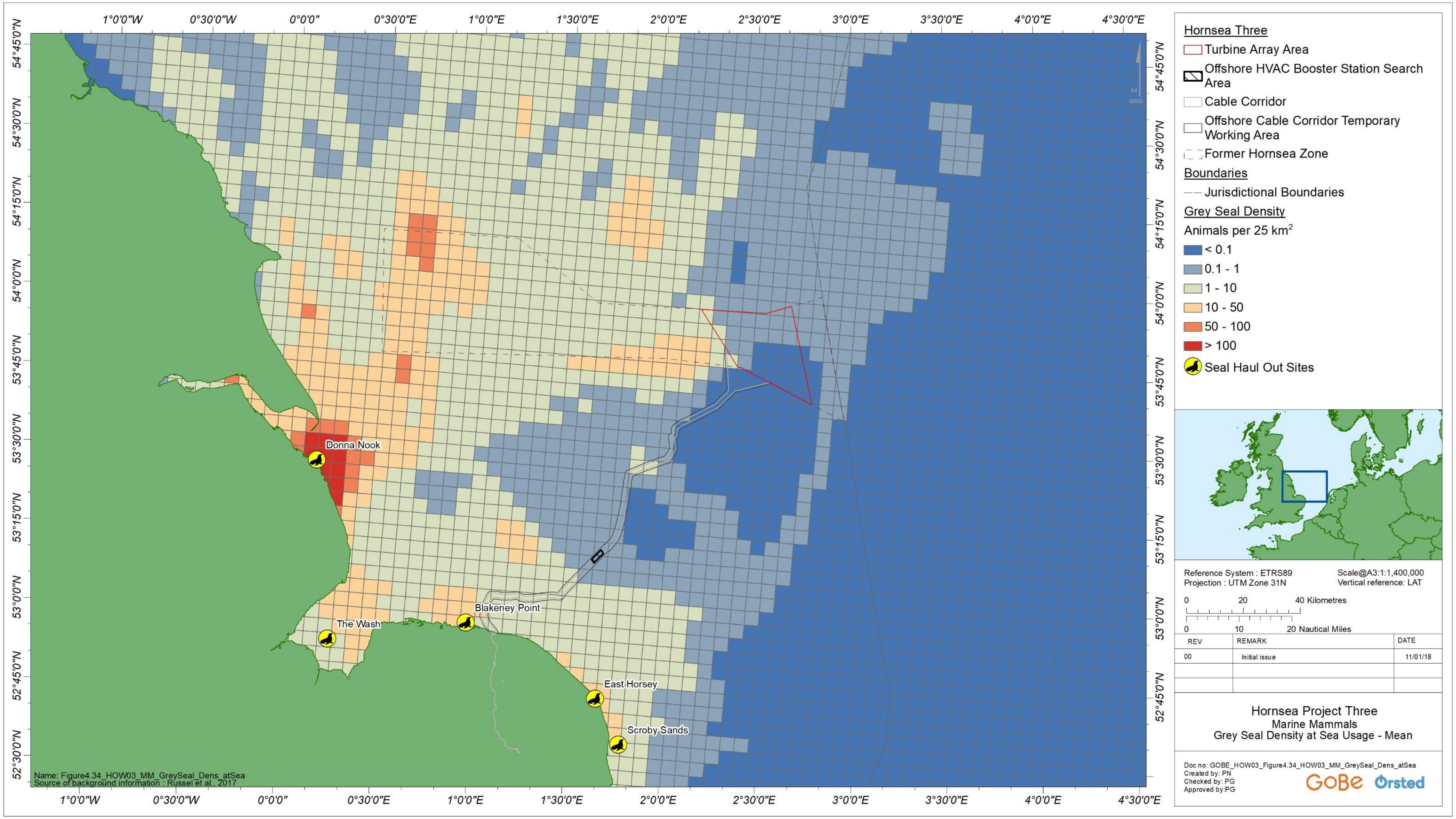


Figure 6.4: Grey seal density At-Sea usage - mean (per 25 km²) for the regional marine mammal study area based on data collected over a 15 year period up to 2015.

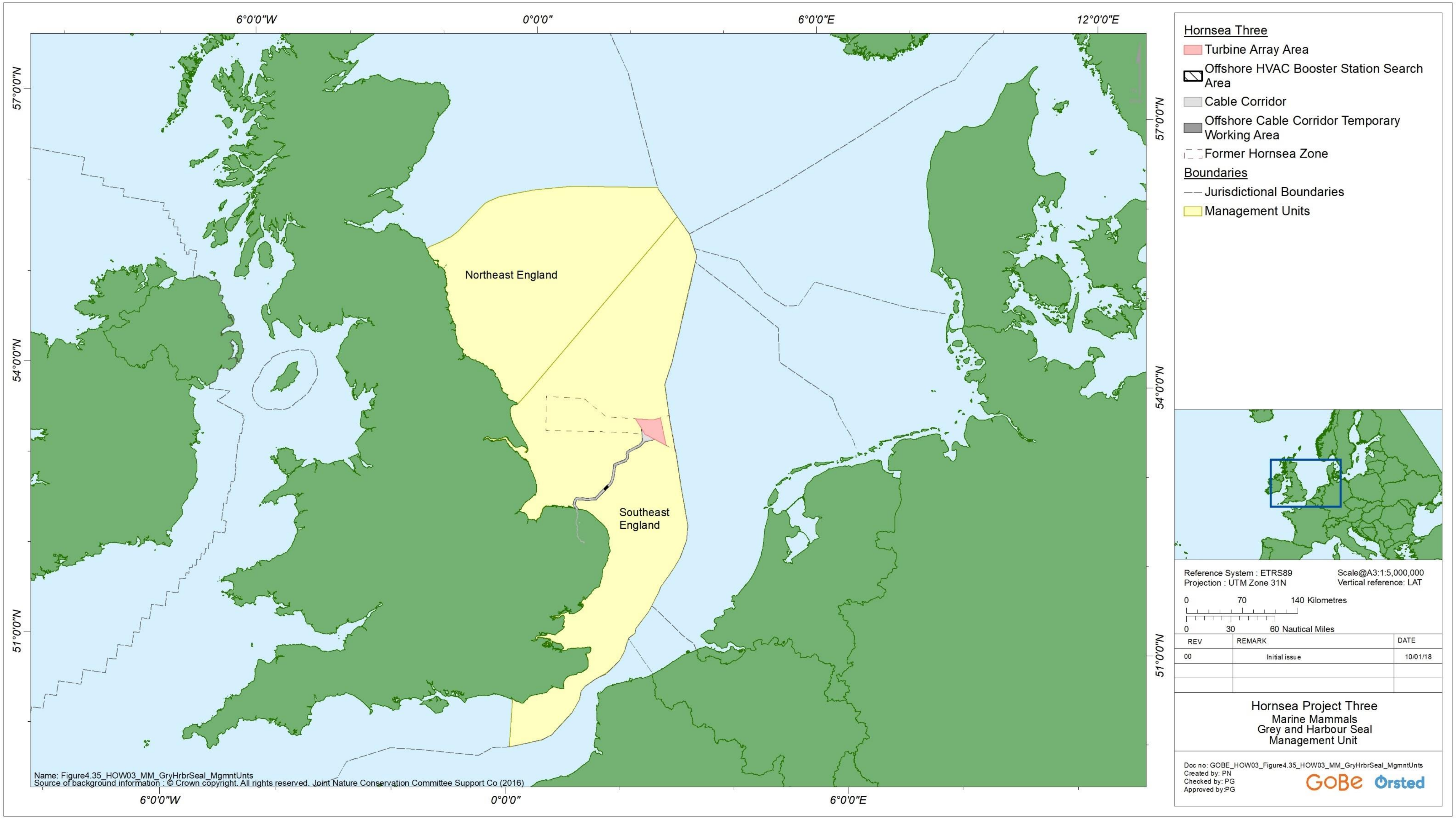


Figure 6.5: Seal Management Units.

Harbour seal

6.4.6.16 The majority of the UK population of harbour seal is found in Scottish waters, although the densest concentration of harbour seal haul-out sites is found along the tidal sandbanks and mudflats of The Wash in East Anglia, Blakeney Point, Donna Nook, and Scroby Sands (SMRU, 2004) (see Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report, Figure 4.36) where animals haul-out to breed and moult. The Wash and North Norfolk Coast support the largest colony of harbour seal in the UK (7% of the total UK population).

6.4.6.17 Boat based surveys of the former Hornsea Zone study area recorded harbour seal throughout the survey area. In total, 147 harbour seals were recorded. This equated to an approximate absolute density within the former Hornsea Zone study area of 0.039 animal's km^{-2} and a relative abundance of 167.2 individuals.

6.4.6.18 Harbour seal at sea usage data provided by SMRU confirm that harbour seal is present throughout the Hornsea Three array area and offshore cable corridor (Figure 6.6) with usage highest nearest to the main haul-out sites in The Wash. Telemetry data also showed that animals travel throughout the Hornsea Three marine mammal study area, particularly in proximity to the coast. Historical WWT aerial survey data (WWT, 2006) also recorded seal along the coastline to the north and south of The Wash and in the area coinciding with the Hornsea Three array area and the offshore cable corridor (see Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report, Figure 4.5).

6.4.6.19 Using SMRU data, the average modelled surface densities across the former Hornsea Zone study area was calculated at 0.849 animal km^{-2} with a total abundance of 315.5 animals. The surface density estimates show a clear density gradient across the former Hornsea Zone with the highest harbour seal densities in the southwest (0.28 animals km^{-2}) and the lowest densities in the north and east (<0.1 animals km^{-2}) (Figure 6.6).

6.4.6.20 Female harbour seals rely on building up fat reserves prior to lactation as their foraging range is reduced when they have pups. Therefore, harbour seals are likely to be most sensitive to disturbance during the breeding period when females are lactating since the energetic costs of reduced foraging success may reduce the survival rate of the pups (Lusseau *et al.*, 2012).

6.4.6.21 Harbour seals tend to forage within 40 or 50 km of their haul-out sites; however, studies in the Greater Wash have found that animals can travel between 75 and 120 km when foraging (SMRU, 2011) with some individuals even having been recorded as travelling as far as 220 km (SMRU, 2011).

6.4.6.22 Advice from UK SNCBs is that the assessment of impacts of Hornsea Three on harbour seal should be carried out against the South East England MU (Figure 6.5). The abundance estimate for this MU is 3,567 animals.

6.4.6.23 Table 6.8 summarises the designated sites within the ZOI identified at HRA screening (Annex 1: HRA Screening Report) which have harbour seal listed as a qualifying interest feature. Sites designated for harbour seal that lie within the normal foraging range of this species (SMRU, 2011) from Hornsea Three have been considered within this RIAA.

Table 6.8: European sites with harbour seal as a qualifying interest feature brought forward for further assessment.

Site Name	Distance from Hornsea Three array area and/or offshore cable corridor (km)	Potential impact
The Wash and North Norfolk Coast SAC	0	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Changes in prey availability (Construction/Decommissioning/ Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Klaverbank SCI (Dutch)	11	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Changes in prey availability (Construction/Decommissioning/ Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Doggersbank SCI (Dutch)	42	• Underwater noise from foundation installation (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Changes in prey availability (Construction/Decommissioning/ Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)

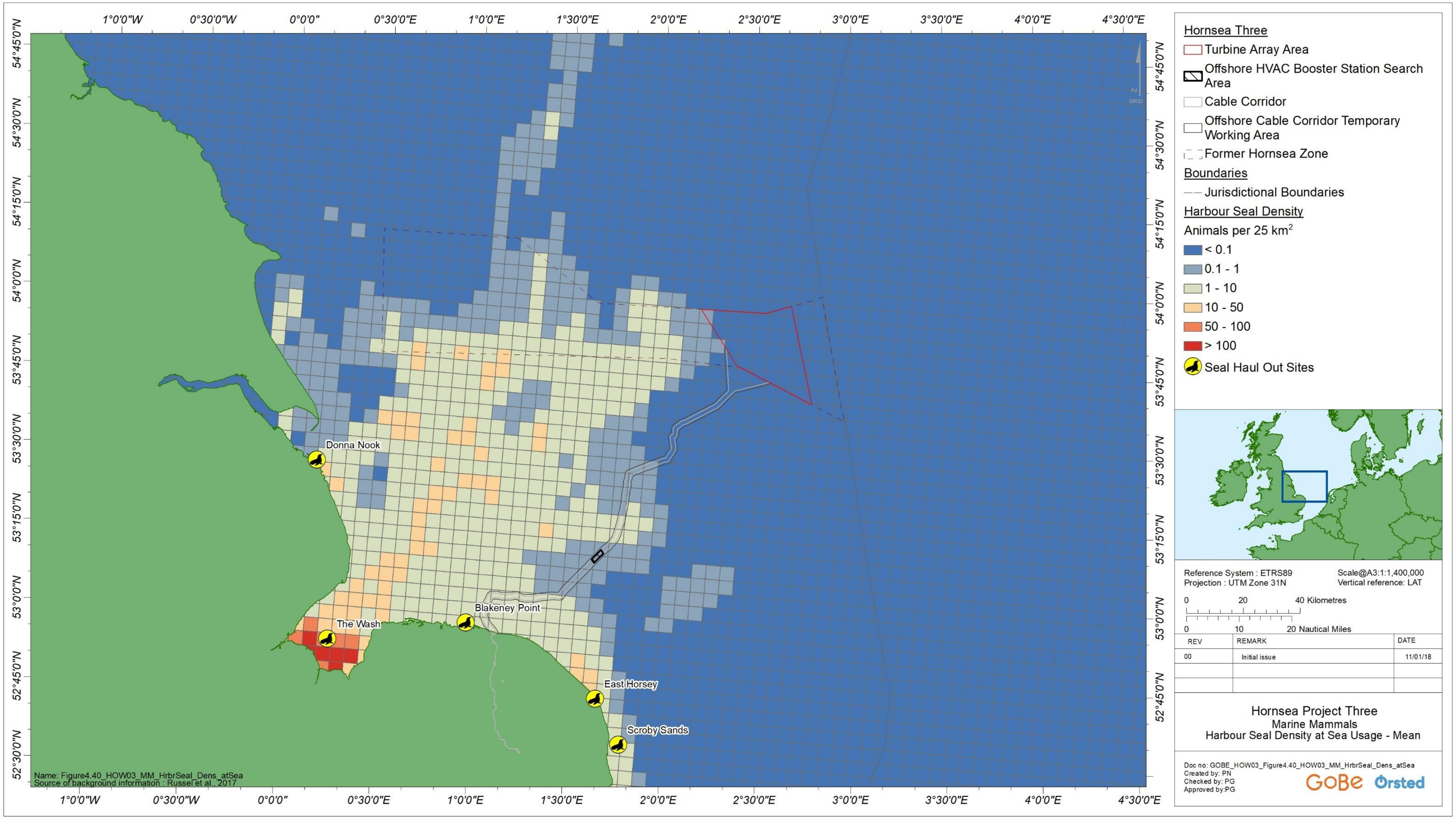


Figure 6.6: Harbour seal density At-Sea usage - mean (per 25 km²) for the regional marine mammal study area based on data collected over a 15 year period up to 2015.

6.4.6.24 Summary

For the purposes of quantifying potential impacts, the following table provides a summary of the mean densities used in the assessment (Table 6.9). The densities used were based on the best available data with consideration given to the most up to date information together with the necessary conservatism applied (i.e. for data collected over similar timeframes the higher value is used).

Table 6.9: Summary of mean density of each of the key species to be used in the impact assessment together with the reference population against which impacts have been assessed.

Species	Average density estimate to be used in impact assessment	Source of density estimate	Relevant MUs for reference population	Abundance of reference population
Harbour porpoise	Grid cell specific density	Modelled surface density estimates from the boat-based acoustic surveys of former Hornsea Zone Study Area	North Sea (NS)	345,373 (246,526 – 495,752)
	0.888 individuals km^{-2}	SCANS-III Block O		
	0.912 individuals km^{-2}	Surface density estimates from the aerial video surveys of the Hornsea Three Study Area		
Grey seal	25 km^2 grid cell specific density surface	Russell *et al.*, 2017	South-East England (SEE) and North East England (NEE) combined	40,040
Harbour seal	25 km^2 grid cell specific density surface	Russell *et al.*, 2017	South-East England (SEE)	6,799 (5,563 – 9,065)

6.5 Assessment of Adverse Effects on Integrity – Alone

6.5.1.1 The potential impacts arising from the construction/decommissioning of Hornsea Three which have been assessed in this RIAA are listed in Table 4.2 along with the maximum design scenario against which each construction/decommissioning phase impact has been assessed.

6.5.1.2 The maximum design scenarios identified in Table 4.2 have been selected as those having the potential to result in the greatest effect on Annex II marine mammals and have been selected from the details provided in the Hornsea Three project description (Environmental Statement volume 1, chapter 3: Project Description). Effects of greater significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

6.5.1.3 The Southern North Sea cSAC has been designated with a specific set of Conservation Objectives and with supporting advice on activities. These are drafted in a different way to other designated sites considered in this assessment. Therefore, the approach taken for this site considers the spatial extent of any potential impacts and how that relates to the cSAC and its features, rather than the number of individuals for which the site is designated. This is detailed further in Section 6.5.2.31 onwards.

6.5.2 Potential impacts – construction/decommissioning

Underwater noise - piling

6.5.2.1 The primary source of subsea noise during construction is from pile-driving activities for the installation of the foundations for the turbines, offshore substations (HVAC and/or HVDC) and accommodation platforms within the Hornsea Three array area and the offshore HVAC booster stations (if HVAC option is selected) along the offshore cable route. Other construction activities, such as drilling of piles and cable installation, also have potential to generate noise levels that could affect marine mammals, however to a much lesser extent than piling noise. It was agreed with JNCC during consultation for Project One and Project Two that the modelling of piling noise was required, and that modelling would not be necessary for other activities (e.g. cable installation). This assumption has been carried forward for Hornsea Three and has been agreed with the EWG (Environmental Statement, volume 2, chapter 4 Marine Mammals). For behavioural impacts on harbour porpoise of the Southern North Sea cSAC the noise modelling is not considered as current SNCB advice states that a standardised precautionary distance of 26 km should be used for HRA purposes.

6.5.2.2 For the maximum design scenario it was assumed that pile-driving would be carried out using maximum blow energies of 5,000 kJ for monopiles and 2,500 kJ for pin-piles (see Table 4.2). However, typically the maximum hammer energy will be considerably less than this and the absolute maximum hammer energy (i.e. up to 5,000 kJ for monopiles and 2,500 kJ for pin-piles) would not be required at all locations. These maximum energy levels were therefore considered to be highly precautionary. A soft-start procedure has been included as one of the designed-in measures adopted for Hornsea Three (Table 4.6). This assumes that piling will be initiated at 15% of the maximum hammer energy for a period of 7.5 minutes (1 strike per 6 seconds), ramping up over a period of 30 minutes until the maximum energy is achieved.

6.5.2.3 The installation programme depends on the foundation and size of turbine selected and may either be carried out by a single vessel throughout the piling sequence, or by two vessels which, in the latter case, would result in periods of concurrent piling. For piling of the offshore HVAC booster stations the installation of either monopile or jacket foundations will be via a single vessel and therefore a concurrent vessel scenario has not been assessed. The project design specifies a period of 2.5 years within which piling activity may occur for all scenarios, divided into two phases, with potential for a gap of up to three years between phases. It is assumed that a worst case would be where there is a gap in piling (as opposed to piling occurring in one continuous period of 2.5 years) as this could potentially affect a larger number of breeding cycles over the lifetime of marine mammals. The maximum design scenarios for the spatial and temporal scenarios are summarised in Table 4.2.

6.5.2.4 Spatially, the maximum underwater noise propogation footprint (the maximum design scenario) for the Hornsea Three array area is likely to arise for the installation of monopiles, where the maximum energy is specified as 5,000 kJ, and where two vessels pile concurrently within the Hornsea Three array area. For this scenario a total of 189 piling days (piling will not occur over the entire day) could occur and could be spread over a two and a half year period, divided into two phases (with two phases totalling two and a half years) and a gap of up to three years between the phases. Similarly, the maximum design scenario for the offshore HVAC booster search area is for installation of monopile foundations using the 5,000 kJ hammer energy. Piling would occur over a maximum of 4.8 days and would be phased over eight months within the two and a half year piling period. For comparison purposes, the assessment also considers piling with a single vessel using the 5,000 kJ hammer energy, with a total duration of piling of 382.8 days within the Hornsea Three array area plus offshore HVAC booster station search area.

6.5.2.5 Temporally, the maximum design scenario is represented by a single vessel installing pin piles (using a maximum 2,500 kJ energy) for jacket foundations, as the duration of piling would be longer compared to monopile foundations. For this scenario a total of 554.4 piling days could occur over a two and a half year piling period, again, split into two phases with a gap of up to three years between phases. For the temporal maximum design scenario there is no piling within the offshore HVAC booster station search area as the scenario with the largest number of piles comprised HVDC converter stations, which are located within the Hornsea Three array area. For comparison purposes, the assessment has also considered the potential for concurrent piling to occur for installation of jacket foundations, and in this case the spatial extent would be increased but the duration of impact is decreased to an estimated 277.2 piling days (phasing as described previously). Similarly, the assessment includes a scenario for piling with a single vessel within the offshore HVAC booster station search area using the 2,500 kJ hammer energy (offshore HVAC booster station with 96 piles instead of the HVAC converter substation), for which the duration is calculated as 28.8 days over eight months.

6.5.2.6 Subsea noise modelling was carried out at three locations within the Hornsea Three array area (south, northwest and northeast) and two locations within the offshore HVAC booster station search area which is located along the Hornsea Three offshore cable route (south and north). These locations were selected to represent the geographical extents of Hornsea Three and to provide a precautionary assessment in terms of proximity to sensitive areas for marine fauna (e.g. areas of highest density or closest to nature conservation designations). A detailed description of the modelling approach is presented in Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report.

Auditory injury

6.5.2.7 Exposure to loud sounds can lead to a reduction in hearing sensitivity, which can be (and in general is) restricted to particular frequencies, dependent on the frequency spectrum of the noise causing it. This reduction (threshold shift) results from physical injury to the auditory system and may be temporary (TTS) or permanent (PTS). In July 2016, the US National Oceanic and Atmospheric Administration (NOAA) released updated guidance on noise assessment metrics for auditory injury (National Marine Fisheries Service, 2016) with revised thresholds for PTS and TTS (henceforth referred to as NOAA thresholds). The NOAA thresholds supersede the thresholds for PTS and TTS onset presented in Southall *et al*. (2007) and in Lucke *et al.* (2009). This report presents PTS and TTS impact ranges for piling events, using the NOAA thresholds for all species.

6.5.2.8 The thresholds are based on a dual criteria approach whereby both should be evaluated and that predicting the largest range of impact, should be considered for the impact assessment. The first metric is pressure based, taken as zero-to-peak sound pressure level (SPL_{zp}) or as peak-to-peak sound pressure level (SPL_{pp}). Any single exposure at or above this pressure based metric is considered to have the potential to cause PTS or TTS, regardless of the exposure duration (cf. Southall *et al*., 2007)). The second metric is energy based, and is a measure for the accumulated sound energy an animal is exposed to over an exposure period, referred to as sound exposure level (SEL) when considering single pulses, or cumulative sound exposure levels (SEL_{cum}) when considering exposure periods with multiple pulses. The sound exposure level metric is based on the 'equal-energy assumption', having its origin in human research, and stating that "*sounds of equivalent energy will have generally similar effects on the auditory systems of exposed human subjects, even if they differ in SPL, duration, and/or temporal exposure pattern"* (Southall *et al*., 2007). While the sound pressure levels are analysed unweighted, the NMFS (2016) describe species (and author) specific frequency filters to be applied before the sound exposure level is calculated. The threshold values for PTS and TTS are given in Table 6.10 and details on the thresholds are provided in the following section.

6.5.2.9 Only PTS is considered as auditory injury in this assessment. This follows JNCC guidance on the prevention of injury and disturbance to European Protected Species (EPS) (JNCC, 2010b). It is considered that assessment of auditory injury using PTS thresholds is sufficiently precautionary and allows a focus on where the larger risks of hearing damage are and to ensure that these risks are mitigated. In addition, the ranges of TTS overlap with disturbance ranges and many animals will actively avoid hearing damage by moving away or spending more time at or near the surface and therefore the consequences of any behavioural change are captured in the assessment of disturbance. Further specific detail on the underwater noise modelling can be found in Environmental Statement volume 2, chapter 4: marine mammals.

Table 6.10: Thresholds for PTS and TTS auditory injury adopted for the assessment.

Parameter (unit)	Harbour porpoise (HF cetacean)	Phocid seal (PW)
PTS		
SPL_{zp} dB re 1 µPa no weighting	202	218
SEL_{cum} dB re 1 µPa²s NOAA weighted, species	155	185
TTS		
SPL_{zp} dB re 1 µPa no weighting	196	212
SEL_{cum} dB re 1 µPa²s NOAA weighted, species	140	170

Behavioural effects – Disturbance from piling activities

6.5.2.10 Behavioural responses to noise are highly variable and are dependent on a variety of internal and external factors. Internal factors include past experience, individual hearing sensitivity, activity patterns, motivational and behavioural state at the time of exposure. Demographic factors such as age, sex and presence of dependent offspring can also have an influence. Environmental factors include the habitat characteristics, presence of food, predators, proximity to shoreline or other features. Responses themselves can also be highly variable, from small changes in behaviour such as longer intervals between surfacing (Richardson 1995) or a cessation in vocalisation (Watkins 1986) to more dramatic escape responses (Götz and Janik 2016). This variability makes it challenging to predict the likelihood of responses to underwater noise from piling. Even where empirical data exist on responses of animals in one particular environment, the context related variability described above makes it difficult to extrapolate from one study to a new situation. It is important to note that all any impact assessment can do, is predict the *potential* for behavioural responses, as definitive predictions of likelihood or magnitude are particularly difficult. Another uncertainty is encountered with the use of the dose-response curves.

6.5.2.11 Two approaches have generally been used in UK EIA and HRA for underwater noise, the traditional approach being the use of a fixed threshold value for determining an impact area, similar to the approach for auditory injury as detailed above. The use of a fixed threshold assumes that all animals within the predicted impact area will display a behavioural reaction, while none of the animals outside this area will react. A second approach, is the adoption of a dose-response function, assuming that the proportion of animals displaying a behavioural reaction will depend on the received sound level. The characteristics of the received sound changes (e.g., received level decreases but other features of the sound may also change) with increasing distance to the sound source, and with it the proportion of animals reacting to the sound.

6.5.2.12 The idea behind the dose-response method is that not all animals react in the same way to sound levels, and that the probability of response varies as a function of received level. This is supported by several studies investigating the displacement of animals by piling sound (e.g. Brandt *et al*. 2011, Dähne *et al*. 2013, Russell *et al*. 2016). Using a dose-response function that allows for the calculation of the portion of animals reacting to a certain sound level therefore represents a more realistic approach compared to using a fixed threshold.

6.5.2.13 For the dose-response assessment a series of isopleths were used, i.e. contours of equal sound levels around the sound source, with a stepwise decreasing unweighted single strike SEL of 180 to 120 dB re 1 μPa²s, with a step size of 5 dB.

6.5.2.14 Temporally, piling could occur up to a maximum of 554.4 days over a 2.5 year, two phase piling period, with a gap of up to three years between phases within the Hornsea Three array area, therefore, within the context of the life cycle of each species, piling could potentially lead to a reduction in reproductive success over up to a maximum of four breeding cycles depending on the exact timing and duration of each phase.

6.5.2.15 The duration of piling within the offshore HVAC booster station search area will be much shorter than for piling within the Hornsea Three array area, with a maximum duration of 4.8 days for monopiles and 28.8 days for jacket foundations (both phased over eight months). Therefore, although the spatial extent of effects could extend beyond the boundaries of the marine mammal study area within the context of the life cycle of the species, only one breeding cycle may be affected and therefore the duration of effects is short term.

6.5.2.16 The noise modelling results demonstrated that the highest impact ranges for single strike SEL (SELss) were found at the northeast modelling location within the Hornsea Three array (Hornsea Three NE) and at the south modelling location within the HVAC search area (HVAC S). The ranges from these two locations are used for the basis of this assessment of disturbance.

6.5.2.17 There are a number of factors that should be considered when interpreting the number of animals predicted to experience disturbance. A large degree of precaution is built into these predictions to account for uncertainty at various stages of the prediction.

6.5.2.18 One such uncertainty is the density estimate used for each species to calculate the number of animals disturbed. A range of datasets were available, however no single dataset could provide the spatial and temporal coverage or a contemporary estimate over the whole of the potential impact range. Therefore, a range of density estimates were used to estimate the number of animals experiencing behavioural disturbance.

6.5.2.19 In order to calculate the number of individuals that might be predicted to respond to the piling noise using the dose-response approach, the estimated density for the area in-between adjacent contours was multiplied by the total area within each of these contour 'rings' and then multiplied by a value that represents the proportion of animals expected to respond within that contour, based on multiplication factors derived from a dose-response relationship described for each target species in the sections below.

Harbour porpoise

6.5.2.20 The dose-response curve approach has been adopted in the EIA for the assessment of behavioural effects on harbour porpoise however as discussed and agreed with the SNCB's the approach within the RIAA will be to apply the traditional approach, being the use of a fixed threshold value for determining an impact area.

Seals

6.5.2.21 A recent study by Russell *et al.* (2016) on the behaviour of 24 tagged harbour seals during pile driving at an offshore wind farm in the Wash, south-east England provides the opportunity to incorporate recent, empirical data on behavioural responses in seals into piling noise assessments. The authors divided the study area in 5 x 5 km² grid cells and predicted the seal density and a corresponding change in density for each cell between periods of piling and periods of non-piling. SELss values were modelled and averaged across the installation of all piles to generate a mean received SEL in the part of the water column with the lowest (and highest, respectively) predicted level for each of the grid cells. This allowed SEL values to be assigned to the predicted change in seal density. This analysis demonstrated that predicted seal abundance was reduced overall during piling activity across an area with a radius of 25 km from the piling activity, relative to seal abundance when no piling was taking place. It is important to note that during this study displacement was limited to piling activity only and within 2 hours of piling ending, seals were distributed as per during non-piling. Based on the data obtained by Russell *et al* . (2016,), a dose-response curve was derived for depth-averaged received levels (mean SELss) (Figure 6.7) to match those predicted by the noise modelling.

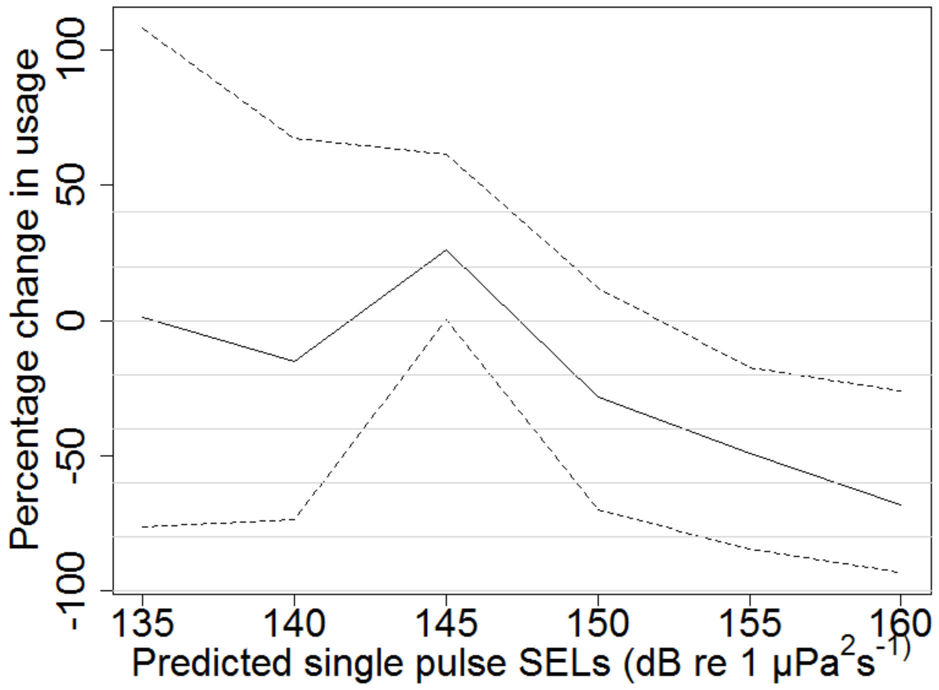


Figure 6.7: The predicted percentage change in seal usage given SELs at 5 dB increments. Please note each increment represents the next 5 dB. E.g. the predicted percentage change in usage value at 135 dB represents the mean for cells with estimated SELs of 135 dB ≤ 140 dB (Environmental Statement volume 5, annex 4.1: Marine Mammal Technical Report provides full detail of how this curve was derived).

Assessment criteria

6.5.2.22 Marine mammals have a highly developed auditory sense and both cetaceans and pinnipeds vocalise underwater to communicate. Odontocete cetaceans (including harbour porpoise) echolocate; producing click trains (rapid series of clicks or buzzing noises) that these species use to locate prey, navigate, and which also may have a communicative role. Passive listening is likely to be important in detecting the presence of predators and other threats. Some species are highly vocal: pelagic dolphin species for example, appear to use whistles as contact calls to coordinate school structure and behaviour. Harbour porpoise appear to click almost continuously in coastal habitats. Underwater vocal activity in other species, including pinnipeds may predominantly occur at certain times of the year associated with breeding or migration.

6.5.2.23 The range of sounds produced varies between species groups, as does the hearing thresholds of these species. Hearing sensitivity is based on both the frequency range of marine mammals (range over which they hear) and their threshold of hearing (i.e. the level of sound at which these animals perceive noise; see Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report). To factor in the sensitivity of species based on their frequency range, different species can be classified into hearing groups (see Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report).

Noise modelling

6.5.2.24 Predictive underwater noise modelling to estimate the noise levels likely to occur as a result of the construction of Hornsea Three has been carried out by Subacoustech Environmental Ltd using the INSPIRE model (as agreed as part of the evidence plan process, see Consultation Report, Annex 1 Evidence Plan). This model represents a change from the approach presented in the PEIR which used the dBSea model. On subsequent review it was determined that the dBSea model lacked empirical support and required further development before it can be confidently used in impact assessmentsassessment. A detailed description of the modelling approach is presented in Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report.

6.5.2.25 The modelling considers a wide range of input parameters, including bathymetry, frequency content and speed of sound in water when calculating noise levels.

6.5.2.26 Modelling has been undertaken at five representative locations covering the Hornsea Three array area and the accompanying offshore HVAC booster station search area, chosen to include proximity to nature conservation designations and varying water depths. The chosen locations are shown in Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report.

6.5.2.27 The Northwest (hereafter referred to as NW) and Northeast (hereafter referred to as NE) locations give a wide spatial coverage of the Hornsea Three array area along the deep-water channel to the north. The South (hereafter referred to as S) location has been chosen to give spatial coverage to the south, showing the greatest potential noise propagation from this region. The two representative HVAC locations, HVAC North (hereafter referred to as HVAC N) and HVAC South (hereafter referred to as HVAC S), give coverage of the offshore HVAC booster station search area in shallower water closer to the coast.

6.5.2.28 The noise modelling results demonstrated that the highest impact ranges were found at the northwest modelling location within the Hornsea Three array (Hornsea Three NW) and at the south modelling location within the HVAC search area (HVAC S). Therefore, the modelling and associated ranges from these two locations are used for the basis of this assessment.

Assessment approach

6.5.2.29 The assessment approach has been discussed with the Marine Mammal EWG for this RIAA. Two approaches have been discussed with regard to the assessment of underwater noise impacts. Details of which are provided below.

6.5.2.30 With regard to the assessment of auditory injury the criteria used to determine the impact ranges were based on recent guidance from NOAA (NMFS, 2016) for all Annex II marine mammal species considered within this assessment and these are applied within the underwater noise modelling (Environmental Statement volume 4, annex 3.1 Subsea noise technical report) which has subsequently been used to inform this element of the assessment.

6.5.2.31 With regard to disturbance effects on harbour porpoise qualifying features, it was advised at the EWG meeting (28th March 2017, see Consultation Report, Annex 1 Evidence Plan), that a uniform approach, based on observed harbour porpoise behavioural evidence be adopted for the disturbance assumptions when characterising disturbance effects (i.e., displacement) of the harbour porpoise Southern North Sea cSAC feature. In developing the COS and Advice on Activities for this site, JNCC applied the 26km Effective Deterence Range (EDR). This is a precautionary range, based on existing studies in Europe where significant disturbance has been observed during piling operations.

6.5.2.32 The extent of the potential for disturbance during underwater piling operations within the Southern North Sea cSAC relates to a defined distance from an individual piling activity. The precautionary distance of 26 km from an individual piling operation within which disturbance behaviour (avoidance behaviour) is anticipated to occur, was identified by JNCC and Natural England following the review of published literature on observed behavioural responses (specifically Tougaard *et al*., 2014 and Dahne *et al*., 2013). The result of the disturbance range is to provide a maximum possible footprint of displacement around each individual piling operation, equating to a maximum potential area per individual piling operation of approximately 2,124km^2 (the area within a circle with a radius of 26km). The actual area of displacement per piling operation will (assuming the range is applied equally in all directions) depend on the location of the piling event relative to the cSAC boundary. Some of the effect radius may fall outside the cSAC boundary, resulting in a maximum possible displacement extent per individual piling operation within the cSAC less than the potential maximum.

6.5.2.33 Harbour porpoise are currently considered as being of FCS across the North Sea MU with a stable overall population. In terms of assessing a significant disturbance effect, the thresholds below have been determined by the SNCBs. A significant effect can be ruled out if the threshold is not exceeded:

- Displacement of harbour porpoise from 20% (spatially) of the seasonal component of the cSAC at any one time (day); and
- Displacement of harbour porpoise, on average, from 10% (spatially) of the seasonal component of the cSAC over the duration of the season.

6.5.2.34 The Southern North Sea cSAC contains both winter and summer harbour porpoise habitat. The effects of the Hornsea Three are considered in the context of the summer component and the winter component of the cSAC .

6.5.2.35 Information on project construction programmes is often represented as a time period within which offshore pilling activities will occur. For Hornsea Three the overall ‘piling window’ is dependent on the foundation type; for monopile foundations with single piling, piling is likely to occur on 319 days phased over a 2.5 year period, while for jacket foundations with single piling, piling is likely to occur on 554.4 days phased over a 2.5 year period. Piling is only anticipated to occur for a percentage of that period, approximately four hours per pile with a maximum of two piles per day, and therefore the duration of disturbance would be for that percentage of the overall piling window. SNCB advice states that, for the purpose of assessment, any piling noise should equate to a 24 hour period (see Consultation Report, Annex 1 Evidence Plan). Therefore, the piling window significantly over estimates the possible piling duration.

6.5.2.36 The MU populations for the features screened into the assessment (grey seal, harbour seal, harbour porpoise) are indicative of the designated site populations (Section 6.4) Therefore, the assessment of impacts has been presented by feature rather than site so as to avoid unnecessary repetition of detail. Conclusions are presented for each impact assessed on a site by site basis in view of their relevant Conservation Objectives (Section 6.2).

Potential effect: auditory injury (PTS) - piling

6.5.2.37 The HRA Screening report (Annex 1: HRA Screening Report) concluded that, for Hornsea Three, the potential for injurious effects would be in relation to noise associated with underwater piling operations.

6.5.2.38 The noise modelling results demonstrated that the highest impact ranges were found at the north west modelling location within the array (OWF NW) and at the south modelling location within the HVAC search area (HVAC S). Therefore, the ranges from these two locations are used for the basis of this assessment.

6.5.2.39 SNCB guidance (JNCC, 2010b) defines injury as PTS, and TTS is not considered injury under EPS licencing as it is temporary and fully recoverable. Understanding and predicting the consequences of PTS for individuals is challenging and for TTS even more so. After small reductions of hearing sensitivity (< 15 dB) recovery is expected to be relatively quick, often within 60 minutes (Kastelein *et al*. 2013). To put this into context, the level of hearing shift at the TTS onset threshold is 6 dB. Therefore, for the majority of the animals within the TTS onset ranges presented here, the duration of the temporary reduction in sensitivity is expected to be short and not likely to be ecologically significant. TTS is only likely to be of concern when it reaches levels where effects could become permanent – and this is covered by the specific assessment of PTS-onset thresholds. Therefore, the assessment of auditory injury is based on the PTS results only.

PTS uncertainties

6.5.2.40 A large degree of precaution is built into these predictions to account for uncertainty at various stages of the prediction process.

6.5.2.41 One such uncertainty is the assumption of the equal-energy-hypothesis used in the prediction of injury ranges as a result of cumulative exposure over multiple pulses. This hypothesis may not hold for all situations due to the complexity of predicting PTS. The equal energy rule over-estimates the effect of intermittent noise since the quiet periods between exposures will allow some recovery compared to noise that is continuously present with the same total SEL (Ward, 1997). A number of studies have demonstrated that the resulting auditory impairment in marine mammals from pulsed sound is less than that from continuous exposure with the same total SEL (Mooney *et al*. 2009, Finneran *et al*. 2010, Kastelein *et al*. 2014). However, NMFS (2016), adopt the equal-energy-hypothesis for multiple pulse sound types, as there is currently no supported alternative method to accumulate exposure.

6.5.2.42 Another uncertainty is the rate at which animals are predicted to swim away from the piling noise. Relatively low swim speeds have been used in the modelling of cumulative exposure. This may be precautionary as several marine mammal species have been observed to increase their swimming speeds in relation to exposure to underwater noise (e.g. Dyndo *et al*. 2015, McGarry *et al*. 2017). This would have the effect of moving animals away faster from the most intense noise, thus reducing their overall exposure and therefore reducing the modelled impact ranges presented here.

6.5.2.43 The modelled piling duration of four hours for the maximum design scenario parameters and three hours for the most likely parameters are considered to be highly precautionary. Typically, installation is expected to last between one and two hours and only a small percentage (likely 5% or less) of piling operations will take longer.

6.5.2.44 The PTS impact areas for harbour porpoise, harbour seal and grey seal are presented in the Environmental Statement volume 2, chapter 4: Marine Mammals.

PTS: Harbour porpoise

6.5.2.45 Using the peak (SPLzp) threshold, the maximum predicted range of PTS was 395 m for the 'worst case' monopile scenario maximum hammer energy of 5,000 kJ and 273 m for the 'worst case' pin pile scenario maximum hammer energy of 2,500 kJ at Location OWF NW (Table 6.11). The corresponding values at Location HVAC S were lower.

6.5.2.46 Using the SELcum threshold the maximum predicted range of PTS was 1,200 m for the 'worst case' pin pile (2,500 kJ) scenario at Location OWF NW (Table 6.11). However, this represents the absolute worst case and will not be representative of the majority of the piling activity. Based on a pin pile hammer energy of 1,750 kJ ('most likely' scenario) the predicted PTS impact range at Location OWF NW using the SELcum threshold reduces to 200 m (Table 6.11).

6.5.2.47 Studies of auditory injury in relation to the frequencies of the noise exposure have suggested that hearing impairment as a result of exposure to piling noise is likely to occur in and around the frequency of the fatiguing signal (Kastelein *et al*. 2013), therefore auditory injury from piling is likely to be in lower frequency bands which would be unlikely to affect the ability of harbour porpoises to communicate or echolocate.

6.5.2.48 Given these impact ranges, alongside the adoption of standard mitigation (e.g. JNCC protocol including the use of an ADD prior to a soft start), the risk of PTS to any harbour porpoise as a result of exposure to piling noise is negligible.

Table 6.11: Harbour porpoise PTS impact area (km²) and impact ranges (m) for locations OWF NW and HVAC S for the worst case and most likely piling scenarios for both monopoles and pin piles.

	Area	Max Range	Min Range	Mean Range	Area	Max Range	Min Range	Mean Range
Worst Case	**Monopile (5,000 kJ)**				**Pin pile (2,500 kJ)**			
OWF NW								
202 SPL_{zp} dB re 1 µPa	0.49	395	394	395	0.23	273	272	273
$NMFS_{HF}$ 155 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	2.74	1,200	600	911
HVAC S								
202 SPL_{zp} dB re 1 µPa	0.16	229	228	229	0.07	153	152	153
$NMFS_{HF}$ 155 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.03	100	100	100
Most Likely	**Monopile (3,500 kJ)**				**Pin pile (1,750 kJ)**			
OWF NW								
202 SPL_{zp} dB re 1 µPa	0.34	328	327	328	0.15	218	217	217
$NMFS_{HF}$ 155 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.12	200	100	193
HVAC S								
202 SPL_{zp} dB re 1 µPa	0.11	188	187	188	0.05	121	120	121
$NMFS_{HF}$ 155 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.03	100	100	100

Conclusions

The Southern North Sea cSAC

6.5.2.49 Based on the information presented above and considering the embedded mitigation (see Table 4.6), there is no indication that the potential for lethality/ injury and hearing impairment effects associated with underwater noise generated from piling activities on the harbour porpoise qualifying feature of this site would lead to a reduction in the viability of the species, a conservation objective of the Southern North Sea cSAC (see Section 6.2.5). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that favourable conservation status is maintained as defined in the Conservation Objectives of this site (see Section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.5.2.50 Based on the information presented above, there is no indication that the potential for lethality/ injury and hearing impairment effects associated with underwater noise generated from piling activities on the harbour porpoise features of this SCI would lead to a reduction in the extent or quality of the habitat in order to maintain the populations, a conservation objective ofthe Klaverbank SCI (see Section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (Section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

PTS: Seal species

6.5.2.51 Using the peak (SPLzp) threshold, the maximum predicted range of PTS was 41 m for the maximum design scenario of 5,000 kJ for monopiles and 29 m for the maximum design scenario of 2,500 kJ at Location Hornsea Three NW (Table 6.12). The corresponding values at Location HVAC S were lower.

6.5.2.52 Using the SELcum threshold, the maximum predicted range of PTS was 100 m for both the maximum design monopile (5,000 kJ) and pin pile (2,500 kJ) scenarios at both Location Hornsea Three NW and HVAC S (Table 6.12).

6.5.2.53 Seals are less dependent on hearing for foraging than cetacean species, but may rely on sound for communication and predator avoidance (e.g. Deecke *et al*. 2002). Hastie *et al*. (2015) reported that, based on calculations of SEL of tagged seals during the Lincs OWF construction, at least half of the tagged seals would have received a dose of sound greater than published thresholds for PTS. Based on the extent of the OWF construction in the Wash over the last ten years and the degree of overlap with the foraging ranges of harbour seals in the region (e.g. see Russell *et al*. 2016), it may be possible that a large number of individuals of the Wash population may have experienced levels of sound with the potential to cause some degree of hearing loss. The Wash harbour seal population has been increasing rapidly over this period and although there are clearly many other ecological factors that will influence the population health, this indicates that predicted levels of PTS are not affecting sufficient numbers of individuals, by a sufficient amount to cause a decrease in the population trajectory. However, despite the uncertainty in the ecological effects of PTS on seals, seals rely on hearing much less than cetaceans and therefore the sensitivity of seals to PTS has been assessed as medium.

6.5.2.54 Based on the impact ranges presented above, alongside the adoption of standard mitigation (e.g. JNCC protocol including the use of an ADD prior to a soft start), the risk of PTS to any seals as a result of exposure to piling noise is assessed as negligible.

Table 6.12: Seal species PTS impact area (km²) and impact ranges (m) for locations Hornsea Three NW and HVAC S for the maximum design and most likely piling scenarios for both monopiles and pin piles.

	Area	Max Range	Min Range	Mean Range	Area	Max Range	Min Range	Mean Range
Maximum Design	**Monopile (5,000 kJ)**				**Pin pile (2,500 kJ)**			
Hornsea Three NW								
218 SPL_{zp} dB re 1 µPa	0.01	41	40	41	0	29	28	29
$NMFS_{PW}$ 185 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.03	100	100	100
HVAC S								
218 SPL_{zp} dB re 1 µPa	0	25	24	25	0	17	16	17
$NMFS_{PW}$ 185 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.03	100	100	100
Most Likely	**Monopile (3,500 kJ)**				**Pin pile (1,750 kJ)**			
Hornsea Three NW								
218 SPL_{zp} dB re 1 µPa	0	34	33	34	0	23	22	23
$NMFS_{PW}$ 185 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.03	100	100	100
HVAC S								
218 SPL_{zp} dB re 1 µPa	0	20	19	20	0	14	13	14
$NMFS_{PW}$ 185 SEL_{cum} dB re 1 µPa²s	0.03	100	100	100	0.03	100	100	100

Conclusions

The Wash and North Norfolk Coast SAC

6.5.2.55 Based on the information presented above there is no indication that lethality/injury and hearing impairment effects associated with underwater noise generated from piling activities on the harbour seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Wash and North Norfolk Coast SAC (see Section 6.2.2). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.5.2.56 Based on the information presented above there is no indication that lethality/injury and hearing impairment effects associated with underwater noise generated from piling activities on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Humber Estuary SAC (see Section 6.2.3). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.2.57 Based on the information presented above there is no indication that lethality/injury and hearing impairment effects associated with underwater noise generated from piling activities on the grey seal qualifying feature of this site, would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see Section 6.2.34). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.34). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Klaverbank SCI

6.5.2.58 Based on the information presented above, there is no indication that the potential for lethality/injury and hearing impairment effects associated with underwater noise generated from piling activities on the harbour and grey seal features of this SCI would lead to a reduction in the extent or quality of the habitat in order to maintain the populations, a Conservation Objective of the Klaverbank SCI (see Section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.2.59 Based on the information presented above, there is no indication that the potential for lethality/injury and hearing impairment effects associated with underwater noise generated from piling activities on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbanks SCI (see Section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.2.60 Based on the information presented above and with respect to the Conservation Objectives for the SAC potentially impacted, the potential for lethality/injury and hearing impairment effects associated with underwater noise generated from piling activities on the grey seal feature of this site would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordzeekustzone SAC/ Noordzeekustzone II SCI (see Section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.8). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

<u>Potential effect: Disturbance/displacement</u>

<u>Behavioural disturbance: Southern North Sea cSAC (harbour porpoise)</u>

6.5.2.61 For the Southern North Sea cSAC, the only UK European site with harbour porpoise as a feature, the driver behind the CO 'there is no significant disturbance of the species' is to ensure that any displacement as a result of disturbance is not significant in terms of extent and duration. The COs and Advice on Activities package for the site, suggests that there is potential for disturbance of the harbour porpoise feature within the the precautionary range of 26 km from piling activity.The worst case consequence of disturbance is that harbour porpoise may be displaced from the area affected, essentially preventing access to an area of the European site habitat. The screening for LSE for Hornsea Three, concluded that the potential for significant effect would be from disturbance due to noise associated with underwater piling operations. The assessment considers firstly the maximum one-off effect (with a 20% threshold based on draft CO advice), followed by the seasonal (temporal) effect (with a 10% average threshold based on draft CO advice)

Potential for disturbance effects

6.5.2.62 There are four main components of Hornsea Three that require foundation piling and two types of foundation, that involve piling, that could be used for each of those components:

- Monopile foundations with concurrent piling;
    - Up to 300 WTG foundations (15 m diameter),
    - Up to 3 offshore accommodation platforms,
    - Up to 12 HVAC collector substations; and
    - Up to 4 offshore HVDC converter substations.
- Jacket foundations with single piling;
    - Up to 300 WTG foundations (four piles per foundation totalling 1200 piles),
    - Up to 3 offshore accommodation platforms,

- Up to 12 HVAC collector substations; and
- Up to 4 offshore HVDC converter substations.

6.5.2.63 A 26 km buffer has been projected around all potential piling foundation locations. The level of disturbance associated with installation of each foundation (as characterised by spatial overlap of the 26 km with the cSAC) varies depending on the location of each foundation in relation to the Southern North Sea cSAC. This variation can be presented as a range, with the level increasing with pile location proximity to the cSAC (see Table 6.13) for maximum and minimum values). It is not considered appropriate to base the assessment for all foundations on the maximum level of overlap with the cSAC from a single foundation. Whilst representative of a single 'worst case' pile location, for all other piles the value would overestimate the level of spatial effect. This is especially important for the WTGs, where there could be up to 1,200 piles percussively driven into the seabed (jacket foundation, four piles per foundation). Therefore, it is important to consider the range of effect as the Project builds out.

6.5.2.64 Table 6.13 identifies the range of overlap (expressed as a percentage) within the summer component of the cSAC for each piled component of Hornsea Three (noting that the concurrent piling is relevant to WTG foundations only and therefore, ancillary structure extents are not different between the two construction scenarios). The ranges are calculated from the worst and best case piling locations. The "worst case" (maximum spatial cSAC summer component overlap) and "best case" (minimum spatial cSAC summer component overlap) piling locations for the WTGs and HVAC booster substations for Hornsea Three (based on the 26km effect radius) are presented in Table 6.13. Only the spatial extent of concurrent piling has been presented in Figure 6.8 as this represents the maximum design scenario. There are a number of turbines for which there is no spatial overlap, the minimum percentage relates to the minimum area when there is an overlap. There is no spatial overlap with the winter component of the Southern North Sea cSAC, and therefore this component is not considered. Only the HVAC booster station search area has the potential to overlap with the cSAC winter component.

Table 6.13: Range of spatial overlap with the cSAC from piled project components

Project component	Spatial overlap with the summer component of the cSAC (%)		
	Maximum	Minimum	Median
Singular			
WTG	1.6	9.4×10^{-4}	0.8
HVAC booster stations	3.4	2.5	2.9
Concurrent			
WTG	1.83	6.2×10^{-4}	0.92
HVAC booster stations	3.4	2.5	2.9

6.5.2.65 The total level of overlap (WTG and HVAC booster stations) with the cSAC from all piling activities ranges from 5% (1.6% for WTG plus 3.4% for HVAC) to 2.5% for sequential piling and 5.23% (1.83% for WTG plus 3.4% for HVAC) to 2.5% for concurrent piling. No foundation piling under any construction scenario will result in a spatial effect greater than 5.23% on the summer component of the cSAC. Therefore, the maximum value of 20% in any given day will not be exceeded by piling at Hornsea Three.

6.5.2.66 The temporal threshold for the cSAC relates to piling anticipated to occur within the seasonal component (April – September, 183 days; October – March 182 days). The maximum design scenario outlines that piling is likely to occur on 554.4 days phased over a 2.5 year piling phase, which results in approximately 18.5 piling days per month when averaged across the time period. The worst case scenario is based on singular piling. Whilst it is recognised that piling may not be evenly spread across the overall piling window (i.e. not necessarily proportionally distributed across the summer and winter periods), it is unrealistic to assume that it could be feasible for all piling activity to take place within the summer seasons (April to September). This is as a result of the weather downtime, logistical constraints associated with transportation of foundations to site, manoeuvring from one foundation location to the next and the steps involved with preparing to install each pile once at location. Disturbance to the winter component of the cSAC will only occur from the piling of the four offshore HVAC booster stations, which equals a maximum of 4.8 days piling over the winter season.

6.5.2.67 When averaged across the entire piling window, approximately 111 piling days will occur across any one summer season (18.5 piling days per month, April – September). To identify the average spatial extent across a summer season, the 26 km buffer has been applied to each piling location and the mean spatial overlap calculated. The average spatial overlap (disturbance area) within the summer components of the Southern North Sea cSAC from all the pile locations equals 0.54%. To average such an affect across a summer season, the spatial effect is then applied to the approximate number of piles to be installed within each summer season (111 piling days out of a summer season of 183). For days when no piling would occur, a value of 0% is allocated. In this way, the spatial extent of piling disturbance (which would not occur every day) can be averaged across the 6 month period. In any one 6 month summer season, the maximum spatial extent of disturbance equals 0.33%. This value is well below the 10% seasonal effect threshold value.

6.5.2.68 Piling at HVAC booster station search area has the potential to overlap with the winter component of the Southern North Sea cSAC with a maximum spatial extent of 0.58%, which will not exceed the 20% threshold value in any given day. The mean spatial overlap (with the cSAC winter component) from piling at the HVAC booster stations cannot be calculated without the specific piling locations, therefore the maximum overlap of 0.58% has been utilised. Disturbance to the winter component of the cSAC will only occur from piling for the four offshore HVAC booster stations, which equals a maximum of 4.8 days piling on the precautionary assumption that all HVAC sites are installed during the winter. To average this effect across the winter season the spatial effect is applied to the number of piling days within the winter season. Over the 6 month winter season, the maximum spatial extent of disturbance equals 0.015%.

Consideration of return times

6.5.2.69 It is important to consider return time within the assessments, with evidence suggesting that this may range from 'a few hours' to 'between 1 and three days' in Tougaard *et al.*, (2014) to more precise values of 12 hours (e.g. van Beest *et al*, 2016). The timing of return may vary with distance from noise source and also quality of habitat (i.e. motivation to return) Brandt *et al.*, 2016.

6.5.2.70 The maximum duration of piling activity is for 554.4 days, for jacket pin-piles. It is important to note that this time represents the time within which all piles will be installed, and not the total duration of time that underwater noise will be generated (which will only be a fraction of this piling activity time, approximately four hours per pile). When averaged evenly across the piling schedule, there will be 18.5 piling days per month, which could affect the summer component of the cSAC or four days per month which could affect the winter component of the cSAC. The outputs of the maximum spatial overlap at any one time and across the season are based upon a full days piling noise which is an over estimate as piling time is based on a maximum of four hours piling per monopile and a maximum of two monopiles a day. Therefore, there is a period of return time built into the assessment.

6.5.2.71 Each summer season consists of 183 days, and as such there is a considerable amount of time when piling is not occurring and the return of harbour porpoise could be expected. Thompson *et al.*, (2013a) observed a period of 2-3 days after OWF piling of low or absent detections, following which detections returned to their previous level. Consideration has been given to the maximum return time of 72 hours. An additional two days has been added to every piling day when assessing the impact across the summer season. This results in more piling days and return time days than are present within the summer season (333 days out of a maximum of 183). Therefore to represent the extended disturbance period, an average is taken of the spatial overlap from only piling locations that interact with the cSAC. Therefore, the percentage spatial overlap over the summer component, with the addition of the return time, is 0.7%.

6.5.2.72 Only the piling for the HVAC booster stations can overlap with the cSAC winter component (based on the 26 km disturbance area), which equates to a maximum of four piling days over the winter season (182 days). Considering a return time of 72 hours an additional two days has been added onto every piling day, resulting in 14.4 days. Therefore, the percentage overlap over the winter component, with the additional of the return, is 0.046%.

This assessment approach is over precautionary as it assumes no overlap between one set of piling event plus return time and the next piling event plus return time. It additionally considers the HVAC piling occurring during both the winter and summer seasons.

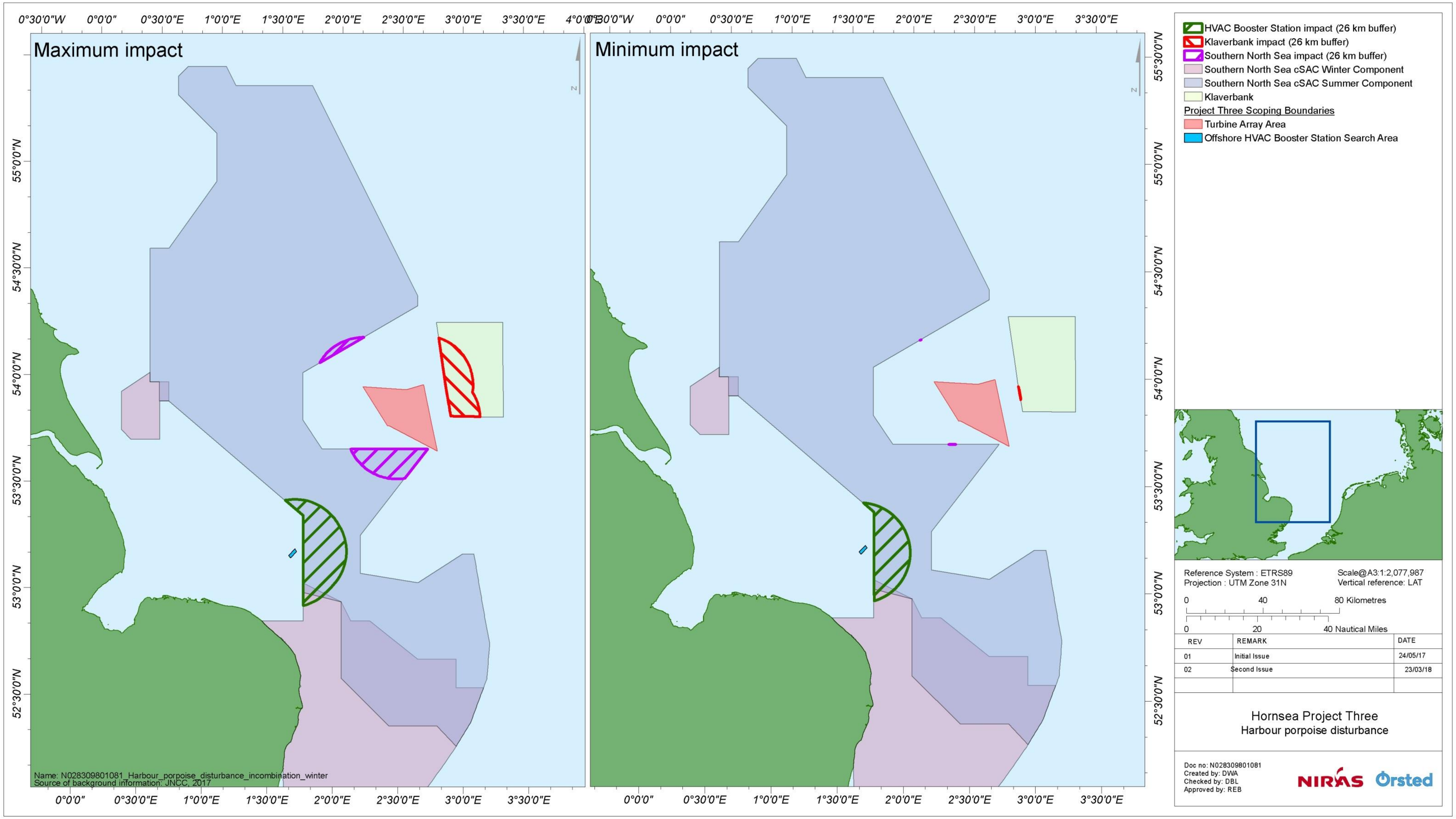


Figure 6.8: Spatial extent of disturbance from concurrent piling at Hornsea Three

Conclusions

Based on the information presented above, due to the maximum spatial overlap being well below specified thresholds, there is no indication that the potential for behavioural effects associated with underwater noise on the harbour porpoise qualifying feature of the Southern North Sea cSAC, would lead to a significant disturbance of the species, a conservation objective of the Southern North Sea cSAC (see Section 6.2.5). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC, from Hornsea Three alone.

Transboundary disturbance effects: Klaverbank SCI

6.5.2.73 Following the approach utilised for assessing disturbance on the Southern North Sea cSAC, the precautionary distance of 26 km, from an individual piling operation within which displacement (avoidance) behaviour is anticipated to occur, will be applied to transboundary sites. The level of disturbance associated with the installation of each foundation varies depending on the location of the foundation. The further away the piling location from the SCI the less spatial overlap.

6.5.2.74 Table 6.14 identifies the range of overlap (expressed as a percentage) with the Klaverbank SCI for the WTGs (HVAC booster station piling will not affect the Klaverbank SCI). The “worst case” (maximum spatial SCI overlap) and “best case” (minimum spatial SCI overlap) piling locations for the WTGs for Hornsea Three (based on the 26km effect radius) are presented in Figure 6.8. Only the spatial extent of concurrent piling has been presented as this represents the maximum design scenario.

Table 6.14: Range of spatial overlap with the Klaverbank SCI from piled project components

Project component	Spatial overlap with Klaverbank SCI (%)		
	Maximum	Minimum	Median
Singular			
WTG	30.1	0.001	15.1
Concurrent			
WTG	34.2	0.094	17.1

6.5.2.75 The total level of overlap (WTG) with the Klaverbank SCI ranges from 30% to 0.03% for sequential piling and 34.2 % to 0.094% for concurrent piling, depending on the location of each WTG.

6.5.2.76 The disturbance occurring from piling events with potential to effect a larger proportion of the SCI, is limited temporally. Whilst there are likely to be immediate, potential disturbance effects of piling on harbour porpoise, a key consideration is whether this disturbance will lead to longer term population effects.

6.5.2.77 The population consequence of behavioural disturbance is difficult to determine due to limited long term studies carried out to date. Harbour porpoise are highly mobile and widespread throughout the North Sea and the proportion of available habitat affected by noise impacts is very small. As such it is expected that, at a population level, harbour porpoise is unlikely to affected by piling over the long term. Although there is the potential for disturbance to lead to displacement, harbour porpoise may range over large distances and the proportion of available habitat affected by piling noise will be comparatively very small. Empirical evidence suggests that movement back into the area will also occur in the short term and populations return to normal after piling is complete. It is therefore considered that given the extent of similar habitat throughout the regional marine mammal study area (as identified within the Klaverbank Conservation Objectives), it is unlikely that displacement of harbour porpoise would lead to any significant population-level effects.

Conclusions

Klaverbank SCI

6.5.2.78 Based on the information presented above, there is no indication that the potential for behavioural effects associated with underwater noise on the harbour porpoise features of this SCI would lead to a significant disturbance of the species, conservation objective of the Klaverbank SCI (see Section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Disturbance: Harbour seal

6.5.2.79 A study of tagged harbour seals in the Wash has demonstrated they were displaced from the vicinity during pile-driving activities. Russell *et al*., (2016) demonstrated that seal abundance was reduced during pile-driving compared to during breaks in piling. The derivation of a dose response curve from these data (see Russell and Hastie, 2018) suggests that significant displacement occurred above received single pulse SEL levels of approximately 150 dB re 1 μPa^2 s. The duration of the displacement was only short-term as seals returned to non-piling distributions within two hours after the end of a pile-driving event. Therefore, the assessment considers the number of indivuals predicted to be disturbed at these levels for each piling scenario.

Single vessel – monopile

6.5.2.80 Figure 6.9 and Figure 6.10 display unweighted noise contours with SEL values decreasing in 5 dB steps from the source, overlain on the harbour seal at-sea density surface as a result of a single operation installing a monopile using 5,000 kJ hammer energy at Locations Hornsea Three NW and HVAC S.

6.5.2.81 The corresponding number of animals predicted to be affected under this scenario are 4.5 seals for location Hornsea Three NW and 3.8 seals for location HVAC S. These represent up to a maximum of 0.07% of the harbour seal reference population (South-East England MU) (Table 6.15). Due to this very low level of predicted impact from the maximum design scenario, the assessment was not repeated for the most likely maximum or average hammer energies.

6.5.2.82 In general, there is little overlap between the impact footprint of the Hornsea Three pile driving locations and the areas where harbour seals are found within the SAC (Figure 6.9) meaning that the potential for impact is very low for wind turbine foundation installation. This is reflected in the very low numbers presented above and in Table 6.15.

Table 6.15: Number of harbour seals experiencing behavioural disturbance during the installation of a monopile using at-sea usage density data (mean and lower and upper 95% CI).

Hammer Energy (kJ)	120 – 180 dB	
	# Seals Impacted	% Population
Hornsea Three NW		
5,000	4.5 (0.8 – 8.2)	3.8 (1.2 – 6.3)
HVAC S		
5,000	3.8 (1.2 – 6.3)	0.06% (0.02 – 0.09)

6.5.2.83 There is a greater degree of overlap with areas of seal usage of the impact footprints from pile driving at the HVAC location (Figure 6.10) although the numbers of animals expected to be disturbed is still very low. Noise levels in the coastal areas with higher seal density are below the levels expected to result in behavioural reactions based on the Russell *et al*., (2016) derived dose response curve and therefore no barrier effect on seals travelling to or from haul outs is expected.

6.5.2.84 Unlike harbour porpoise, harbour seals store energy in a thick layer of blubber, which means that they are more tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Therefore, they are unlikely to be particularly sensitive to short-term displacement from foraging grounds during periods of active piling. Juvenile harbour seals may be more sensitive to displacement from foraging grounds due to a smaller body size and higher energetic needs. Therefore, harbour seals have been assessed as having medium sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events.

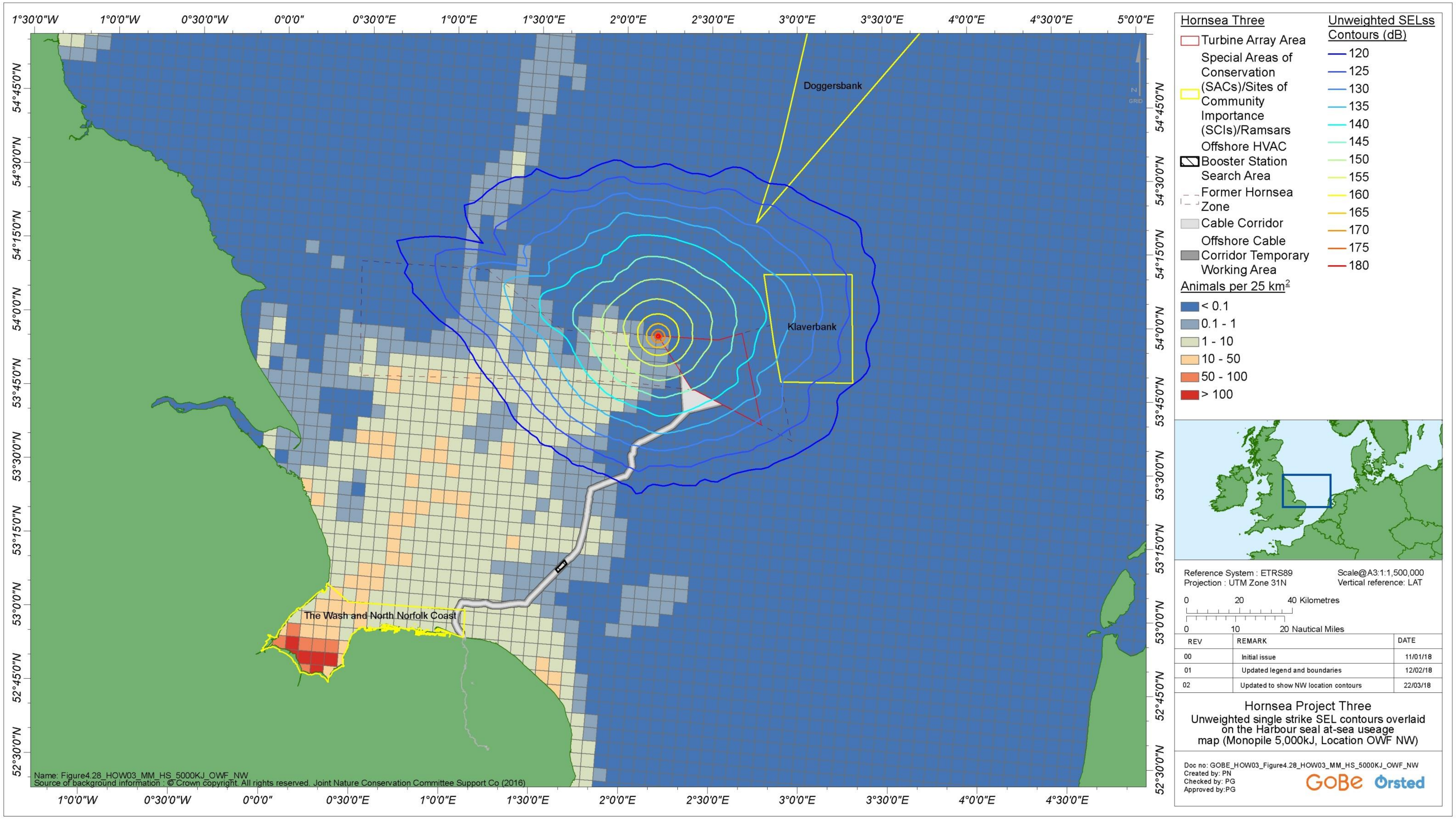


Figure 6.9: Unweighted single strike SEL contours overlaid on the harbour seal at-sea usage map (Monopile 5,000 kJ, Location Hornsea Three NW).

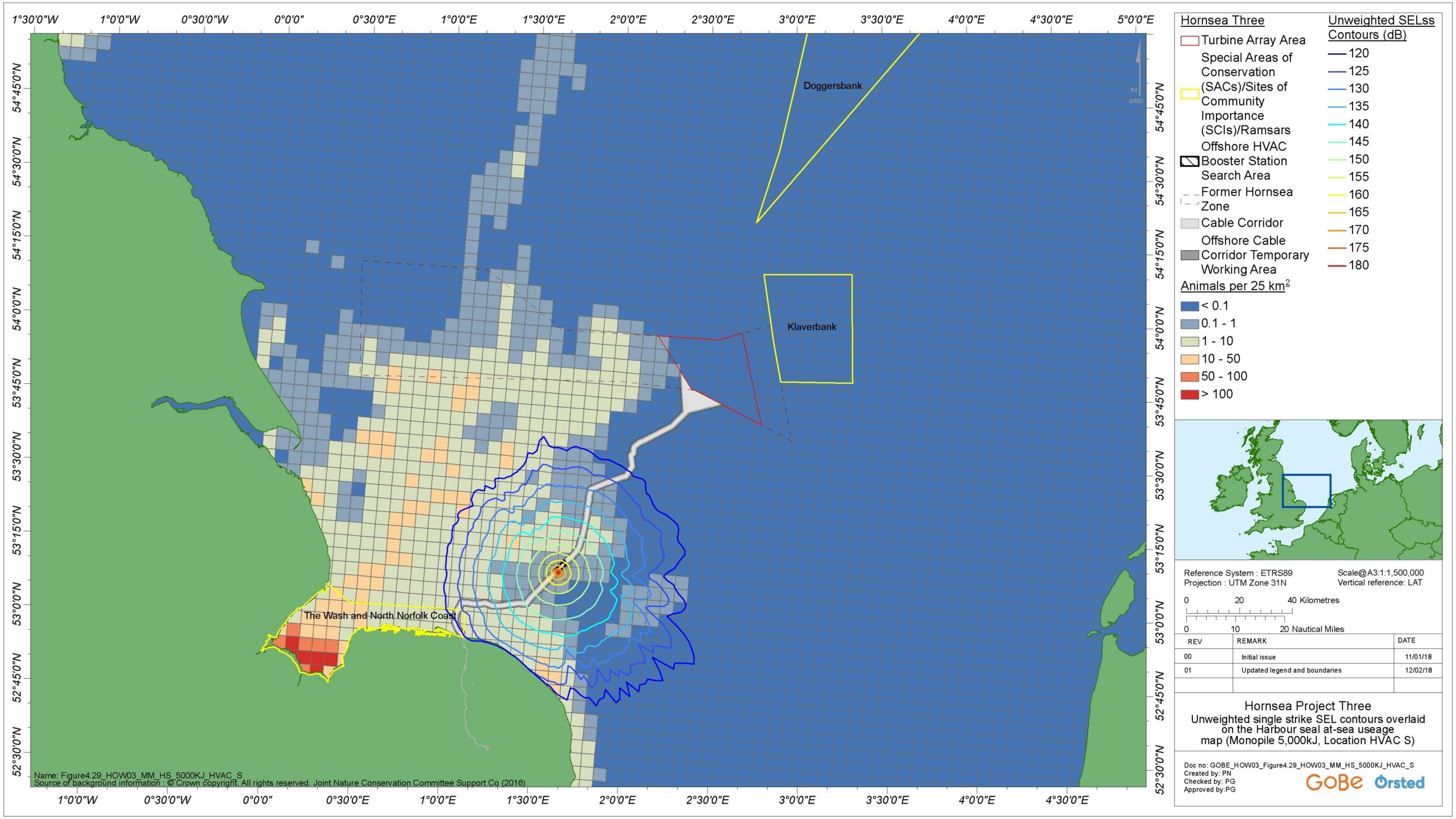


Figure 6.10: Unweighted single strike SEL contours overlaid on the harbour seal at-sea usage map (Monopile 5,000 kJ, Location HVAC S).

Single vessel - pin pile

6.5.2.85 Figure 6.11 and Figure 6.12 display unweighted noise contours with SEL values decreasing in 5 dB steps from the source, overlain on the harbour seal at-sea density surface as a result of a single operation installing a pin pile using 2,500 kJ hammer energy at Locations Hornsea Three NW and HVAC S.

6.5.2.86 The corresponding number of animals predicted to be affected under each scenario are 2.2 seals for location Hornsea Three NW and 1.63 seals for location HVAC S. These represent a maximum of 0.01% of the harbour seal reference population (South-East England MU) (Table 6.16).

6.5.2.87 As above for monopiles, there is very little overlap between the impact footprint of the OWF pile driving locations and the areas where harbour seals are found (Figure 6.11) meaning that the potential for impact is very low for pile driving from wind turbine foundation installation. This is reflected in the very low numbers presented above and in Table 6.16. Due to this very low level of predicted impact from the maximum design scenario, the assessment was not repeated for the most likely maximum or average hammer energies.

6.5.2.88 As above for monopiles, there is a greater degree of overlap with areas of seal usage of the impact footprints from pile driving at the HVAC location (Figure 6.12), although the numbers of animals expected to be disturbed is very low. Noise levels in the coastal areas with higher seal density are below the levels expected to result in behavioural reactions based on the Russell *et al*. (2016) derived dose response curve and therefore no barrier effect on seals travelling to or from haul outs is expected.

Table 6.16: Number of harbour seals experiencing behavioural disturbance during the installation of a pin pile using at-sea usage density data.

Hammer Energy (kJ)	120 – 180 dB	
	# Seals Impacted	% Population
Hornsea Three NW		
2,500	2.2 (0.42 – 3.90)	0.03% (0.01 – 0.06)
HVAC S		
2,500	1.6 (0.47 – 2.79)	0.02% (0.01 – 0.04)

Concurrent piling

6.5.2.89 Figure 6.13 displays unweighted noise contours with SEL values decreasing in 5 dB steps from the source, overlain on the harbour seal at-sea density surface as a result of concurrent operations installing monopiles (5,000 kJ) simultaneously at locations Hornsea Three NW and HVAC S.

6.5.2.90 The corresponding number of animals predicted to be affected is 8.3 seals, which represents 0.12% of the harbour seal reference population (South-East England MU). The magnitude of the impact is therefore considered to be negligible. Due to this very low level of predicted impact from the maximum design scenario, the assessment was not repeated for the most likely maximum or average hammer energies.

Table 6.17: Number of harbour seals experiencing behavioural disturbance during the concurrent installation of 2 monopiles (Hornsea Three NW and HVAC S) using at-sea usage density data.

Hammer Energy (kJ)	120 – 180 dB	
	# Seals Impacted	% Population
Hornsea Three NW + HVAC S concurrent		
5,000	8.3	0.12%

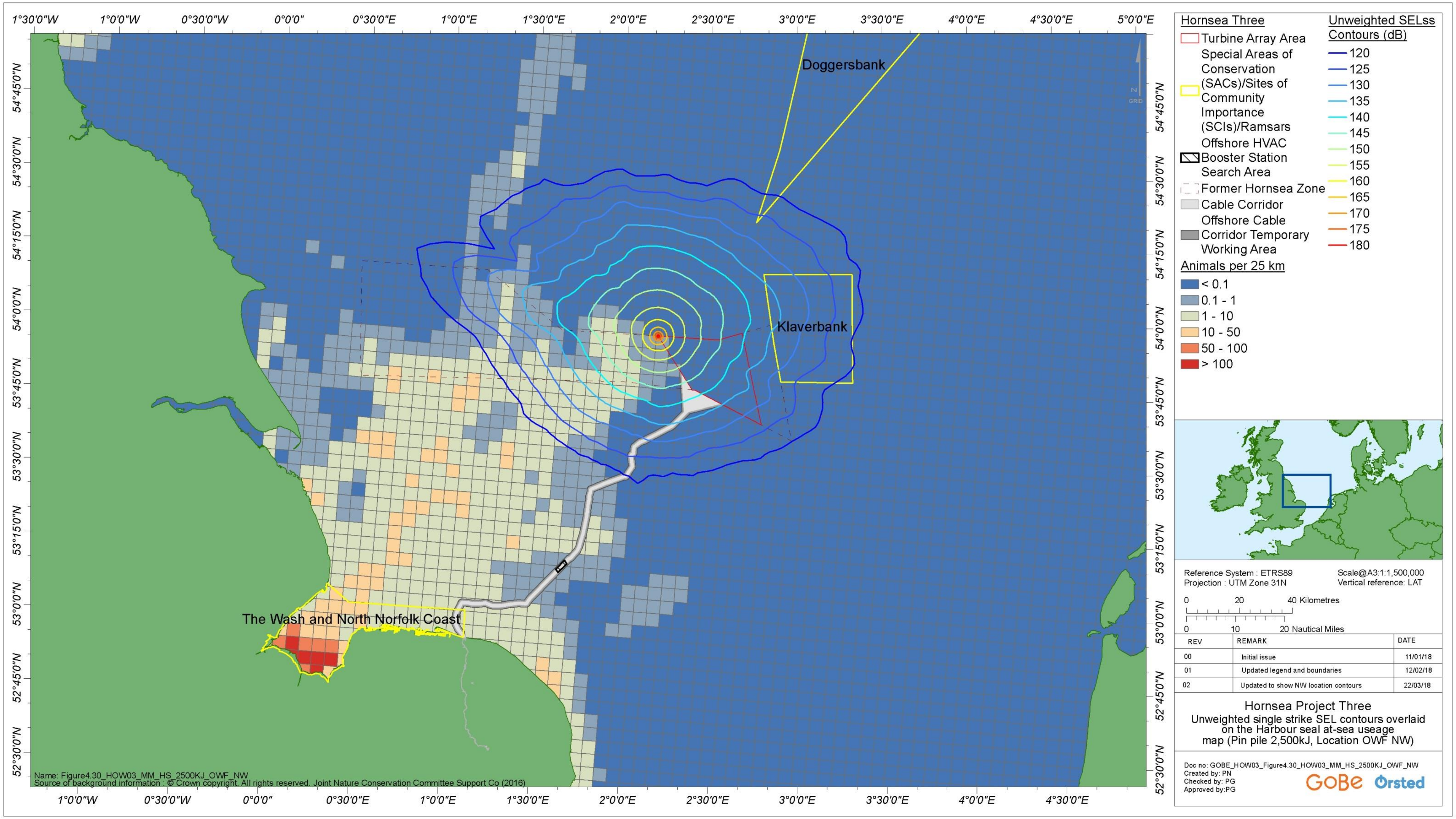


Figure 6.11: Unweighted single strike SEL contours overlaid on the harbour seal at-sea usage map (Pin pile 2,500 kJ, Location Hornsea Three NW).

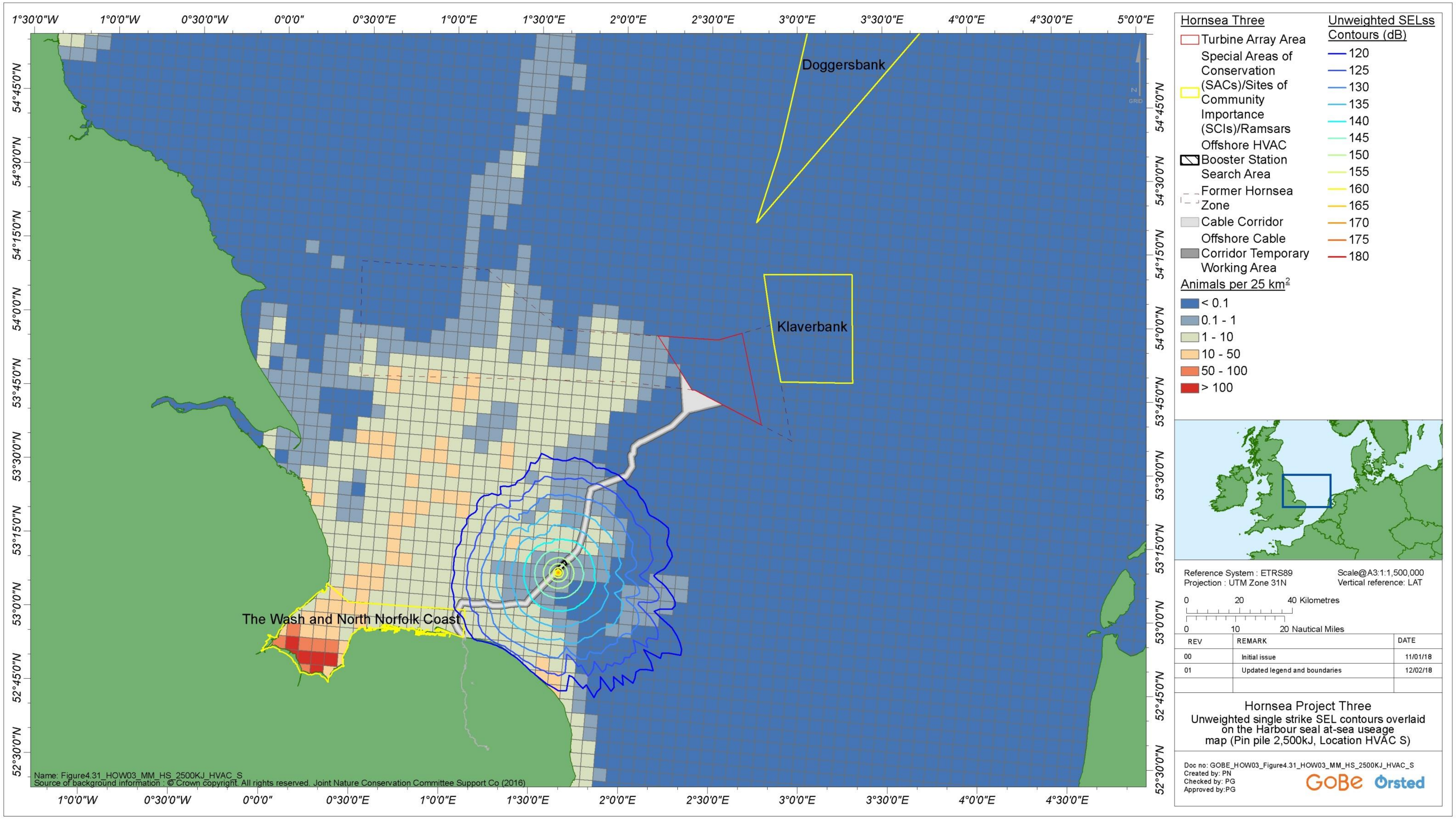


Figure 6.12: Unweighted single strike SEL contours overlaid on the harbour seal at-sea usage map (Pin pile 2,500 kJ, Location HVAC S).

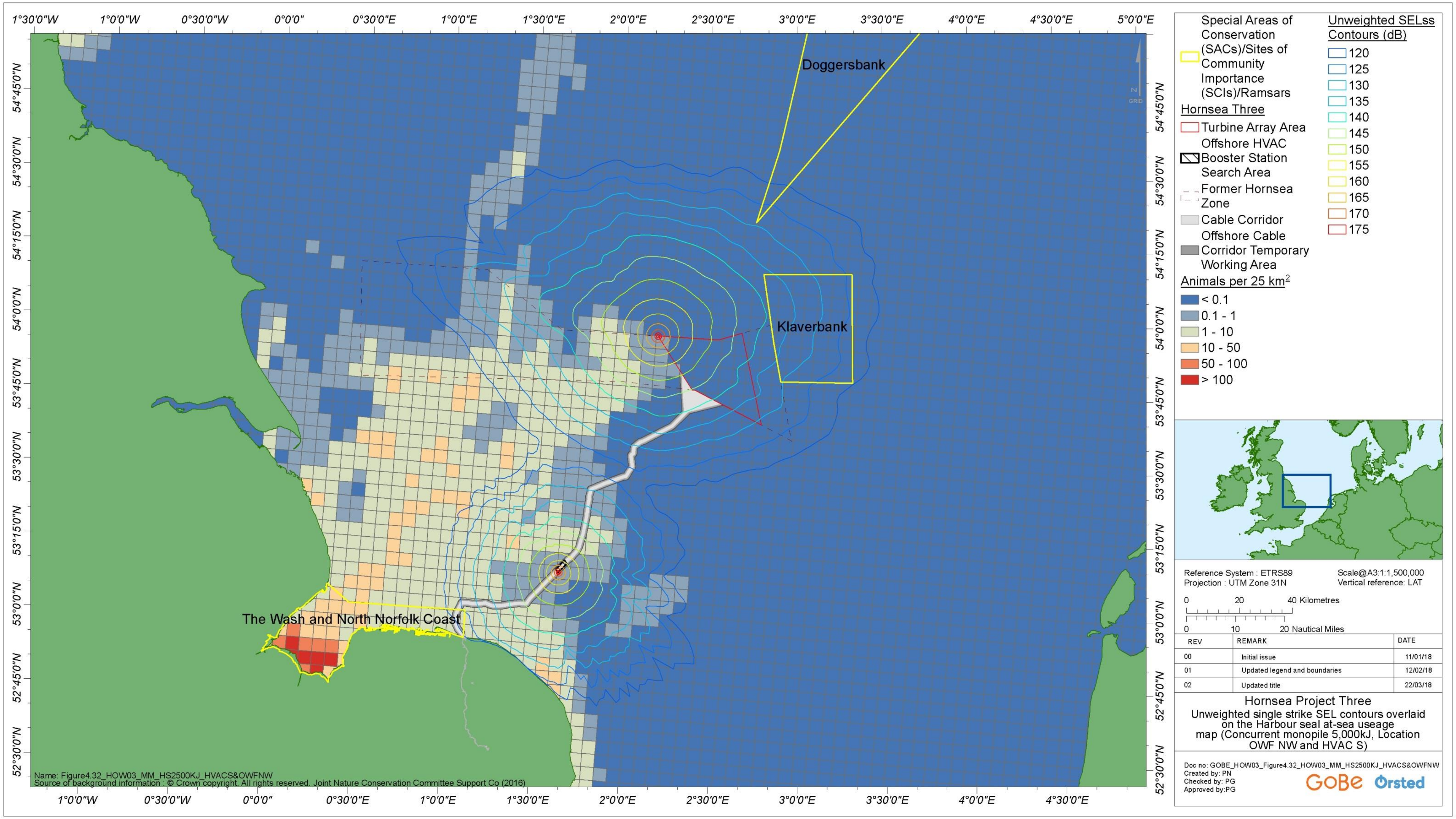


Figure 6.13: Unweighted single strike SEL contours overlaid on the harbour seal at-sea usage map (Concurrent monopile 5,000 kJ, Location Hornsea Three NW & HVAC S).

Disturbance: Grey seal

6.5.2.91 There are no data on the response of grey seals to piling noise. However, grey seals are generally considered to be more robust than harbour seals (based on their larger body size and larger capacity for fasting, their wide ranging and highly mobile nature and the large and increasing North Sea population) and therefore the application of the harbour seal dose response curve is considered precautionary. Therefore, it is expected that grey seals will not experience significant displacement at received single pulse SEL levels lower than 150 dB re 1 μPa^2 s. The duration of any displacement is also expected to be short-term in light of the finding that harbour seal distribution returned to normal within two hours after pile-driving (Russell *et al.,* 2016).

Single vessel – monopile

6.5.2.92 Figure 6.14 and Figure 6.15 display unweighted noise contours with SEL values decreasing in 5 dB steps from the source, overlain on the grey seal at-sea density surface as a result of a single operation installing a monopile using 5,000 kJ hammer energy at Locations Hornsea Three NW and HVAC S.

6.5.2.93 The corresponding number of animals predicted to be affected under each scenario are 48.2 seals for location Hornsea Three NW and 4.7 seals for location HVAC S. These represent 0.12% of the grey seal reference population (combined South-East England and North-East England MU) (Table 6.18).

6.5.2.94 As above for harbour seals, there is very little overlap between the impact footprint of the OWF pile driving locations and the areas that grey seals use (Figure 6.14) meaning that the potential for impact is very low for pile driving from wind turbine foundation installation. This is reflected in the very low numbers presented above and in Table 6.18. Due to this very low level of predicted impact from the maximum design scenario, the assessment was not repeated for the most likely maximum or average hammer energies.

6.5.2.95 As above for harbour seals, there is a greater degree of overlap with areas of seal usage of the impact footprints from pile driving at the HVAC location (Figure 6.15), although the numbers of animals expected to be disturbed is very low. Noise levels in the coastal areas with higher seal density are below the levels expected to result in behavioural reactions based on the Russell *et al*., (2016) derived dose response curve and therefore no barrier effect on seals travelling to or from haul outs or breeding sites is expected.

6.5.2.96 Grey seals are capital feeders and store energy in a thick layer of blubber, which means that they are tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Grey seals are also very wide ranging and are capable of moving large distances between different haul out and foraging regions (e.g. Russell *et al*. 2013). Therefore, they are unlikely to be sensitive to short-term displacement from foraging grounds during periods of active piling. As such, grey seals have been assessed as having low sensitivity to disturbance and resulting displacement from foraging grounds during pile-driving events.

Table 6.18: Number of grey seals experiencing behavioural disturbance during the installation of a monopile using at-sea usage density data (mean and lower and upper 95% CI).

Hammer Energy (kJ)	# Seals Impacted	% Population
Hornsea Three NW		
5,000	48.2 (7.7 – 89.5)	0.12% (0.02 – 0.22)
HVAC S		
5,000	4.7 (0.5 – 9.0)	0.01% (0.00 – 0.02)

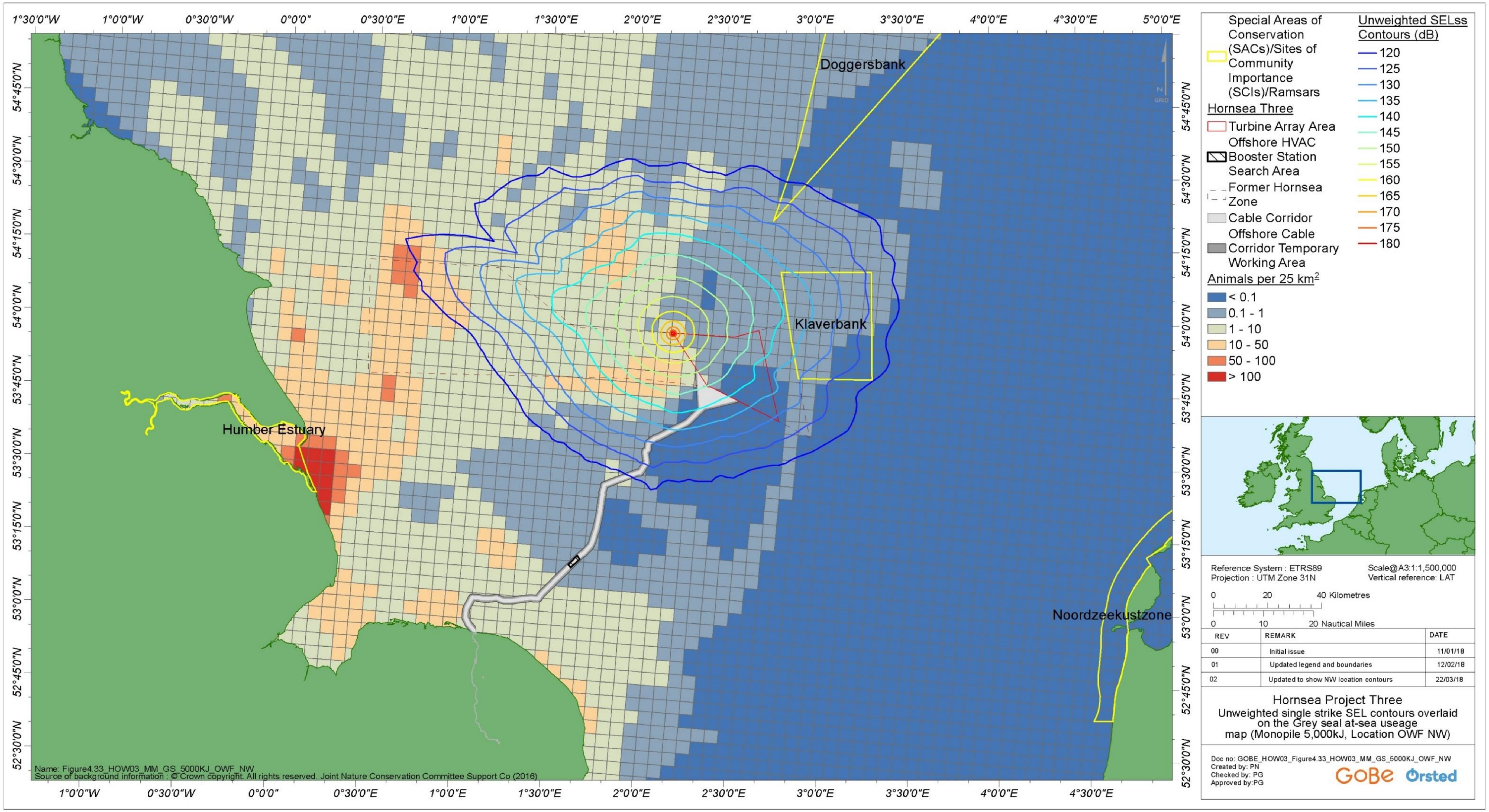


Figure 6.14: Unweighted single strike SEL contours overlaid on the grey seal at-sea usage map (Monopile 5,000 kJ, Location Hornsea Three NW).

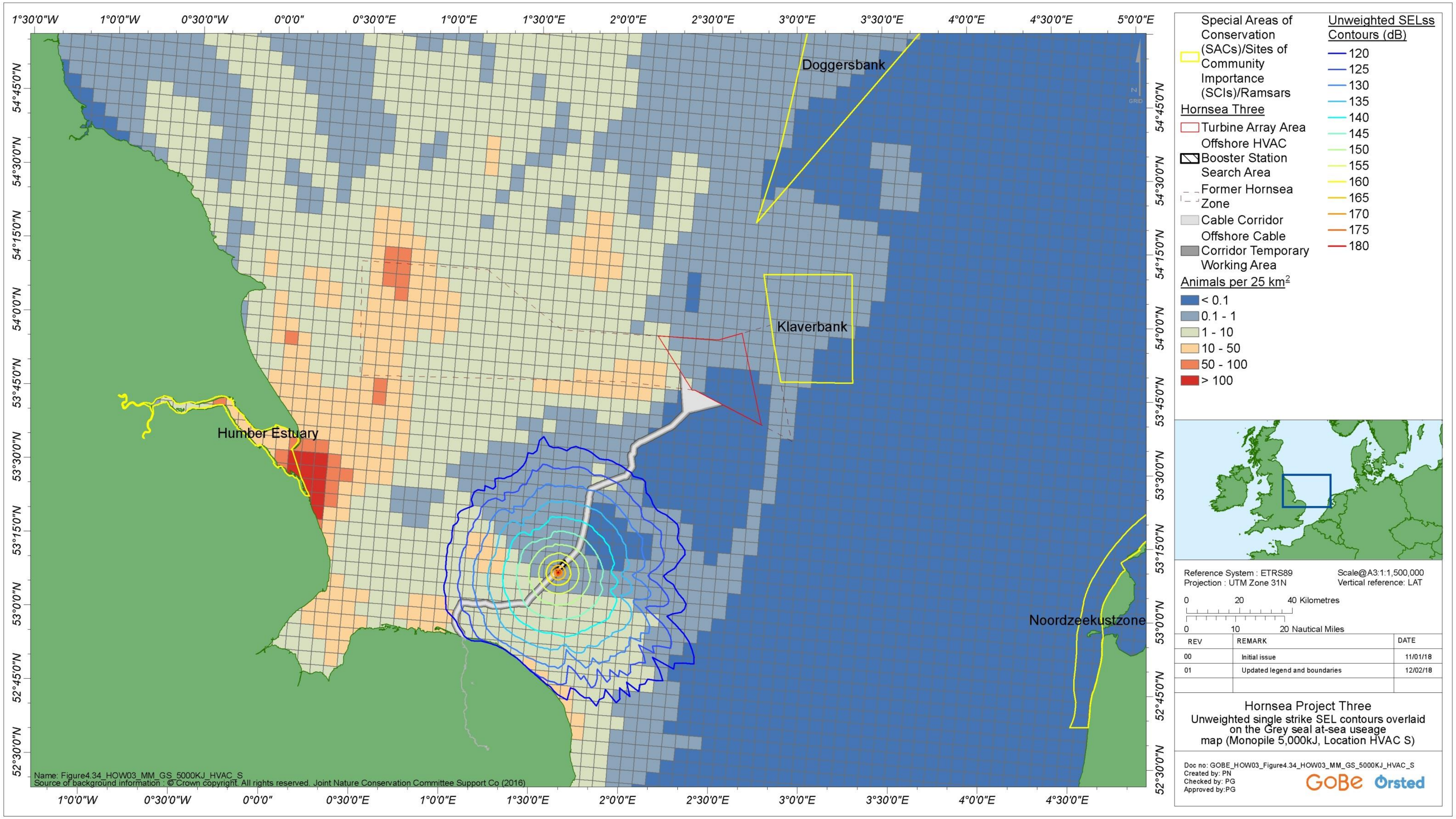


Figure 6.15: Unweighted single strike SEL contours overlaid on the grey seal at-sea usage map (Monopile 5,000 kJ, Location HVAC S).

Single vessel – Pin pile

6.5.2.97 Figure 6.16 and Figure 6.17 display unweighted noise contours with SEL values decreasing in 5 dB steps from the source, overlain on the grey seal at-sea density surface as a result of a single operation installing a pin pile using 2,500 kJ hammer energy at Locations Hornsea Three NW and HVAC S.

6.5.2.98 The corresponding number of animals predicted to be affected under each scenario are 24.8 seals for location Hornsea Three NW and 2.7 seals for location HVAC S. These represent a maximum of 0.06% of the grey seal reference population (combined South-East England and North-East England MU) (Table 6.19). Due to this very low level of predicted impact from the maximum design scenario, the assessment was not repeated for the most likely maximum or average hammer energies.

Table 6.19: Number of grey seals experiencing behavioural disturbance during the installation of a pin pile using at-sea usage density data (mean and lower and upper 95% CI).

Hammer Energy (kJ)	120 – 180 dB	
	# Seals Impacted	% Population
Hornsea Three NW		
2,500	24.8 (4.8 – 45.2)	0.06% (0.01 – 0.11)
HVAC S		
2,500	2.7 (0.3 – 5.1)	0.01% (0.00 – 0.01)

Concurrent piling

6.5.2.99 Figure 6.18 displays unweighted noise contours with SEL values decreasing in 5 dB steps from the source, overlain on the grey seal at-sea density surface as a result of concurrent operations installing monopiles (5,000 kJ) simultaneously at locations Hornsea Three NW and HVAC S.

6.5.2.100 The corresponding number of animals predicted to be affected is 53 seals, which represents 0.13% of the grey seal reference population (combined South-East England and North-East England MU) (Table 6.20). As such, the magnitude is deemed to be negligible. Due to this very low level of predicted impact from the maximum design scenario, the assessment was not repeated for the most likely maximum or average hammer energies.

Table 6.20: Number of grey seals experiencing behavioural disturbance during the concurrent installation of 2 monopiles (Hornsea Three NW and HVAC S) using at-sea usage density data.

Hammer Energy (kJ)	120 – 180 dB	
	# Seals Impacted	% Population
Hornsea Three NW + HVAC S concurrent		
5,000	53	0.13%

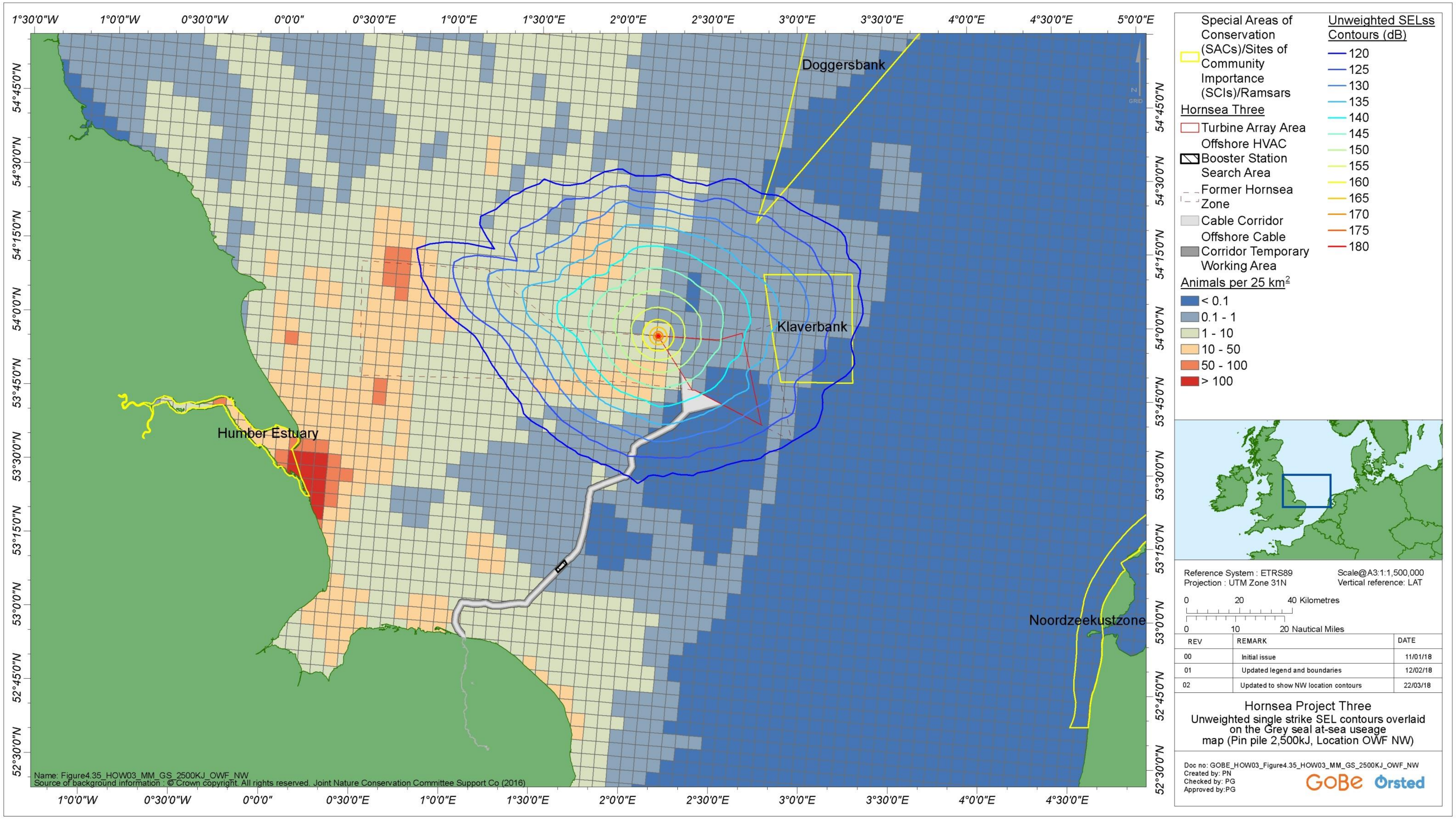


Figure 6.16: Unweighted single strike SEL contours overlaid on the grey seal at-sea usage map (Pin pile 2,500 kJ, Location Hornsea Three NW).

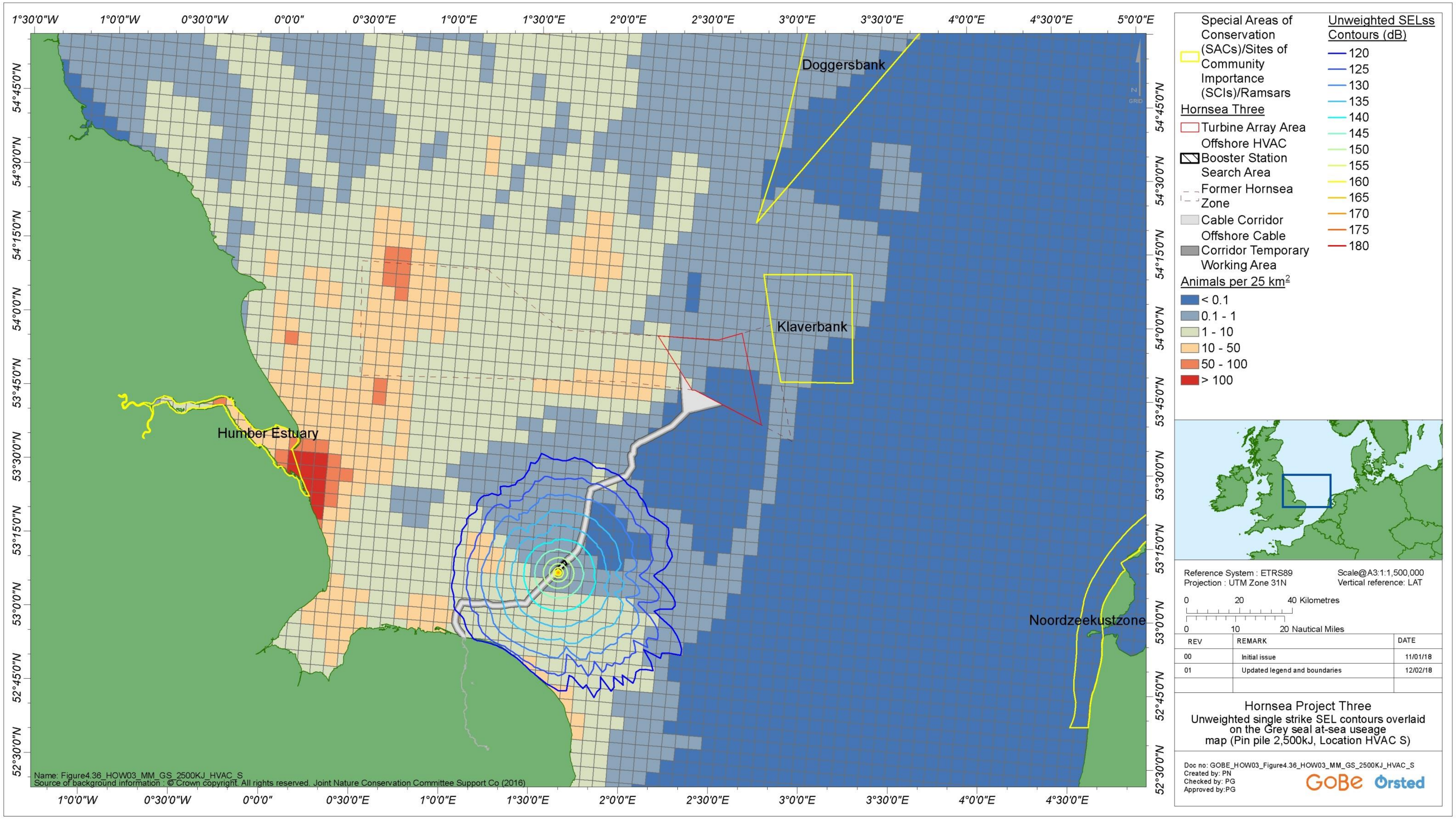


Figure 6.17: Unweighted single strike SEL contours overlaid on the grey seal at-sea usage map (Pin pile 2,500 kJ, Location HVAC S).

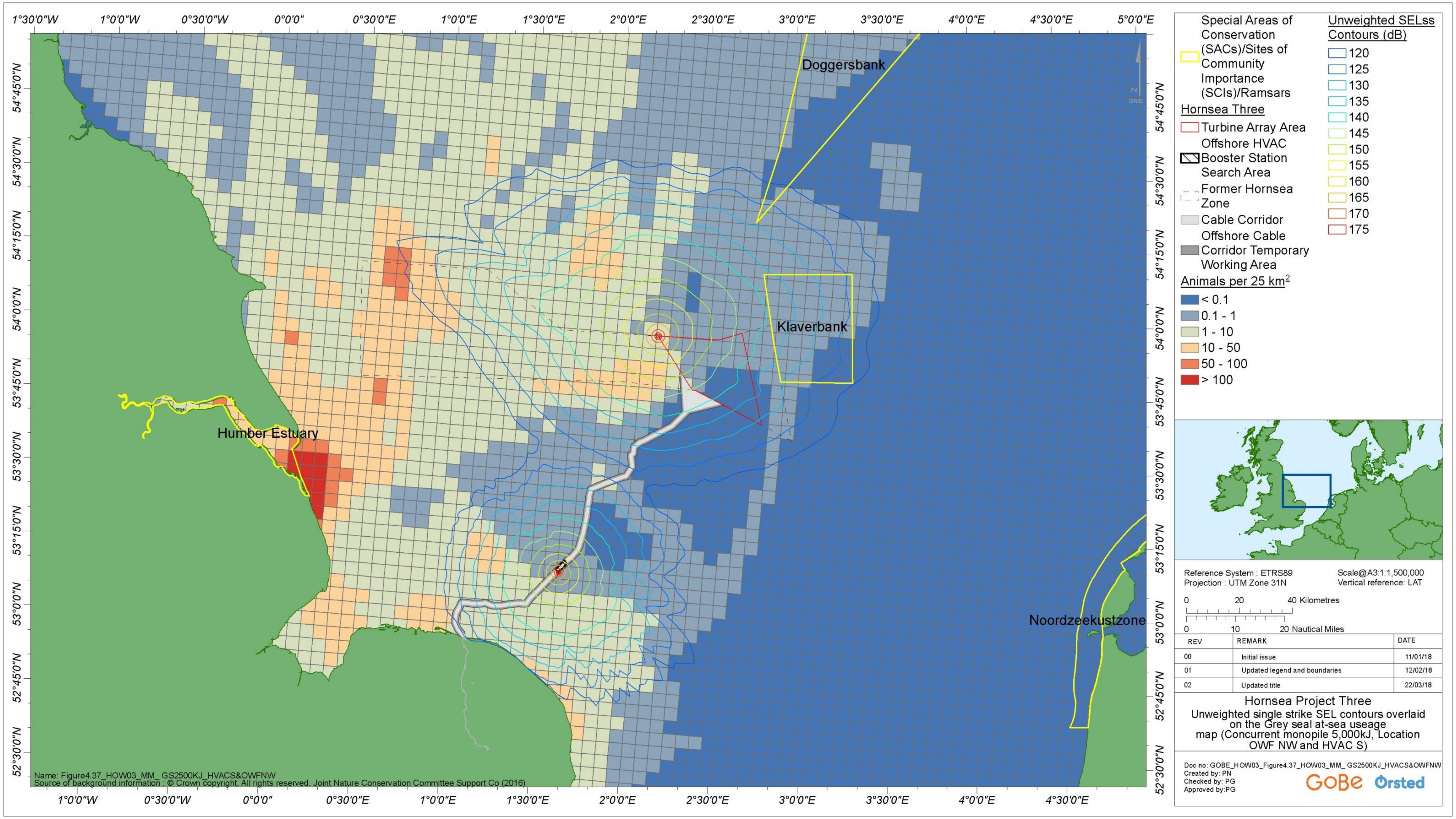


Figure 6.18: Unweighted single strike SEL contours overlaid on the grey seal at-sea usage map (Concurrent monopile 5,000 kJ, Location Hornsea Three NW & HVAC S).

Conclusions

The Wash and North Norfolk Coast SAC

6.5.2.101 Based on the information presented above there is no indication that behavioural effects associated with underwater noise on the harbour seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Wash and North Norfolk Coast SAC (see Section 6.2.2). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.5.2.102 Based on the information presented above there is no indication that behavioural effects associated with underwater noise on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, Conservation Objective of the Humber Estuary SAC/Ramsar (see Section 6.2.3). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.2.103 Based on the information presented above there is no indication that behavioural effects associated with underwater noise on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see Section 6.2.34). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.34). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Klaverbank SCI (harbour porpoise behaviour effects assessed separately)

6.5.2.104 Based on the information presented above, there is no indication that the potential for behavioural effects associated with underwater noise on the harbour seal and grey seal features of this SCI would lead to a reduction in the extent or quality of the habitat in order to maintain the populations, Conservation Objective of the Klaverbank SCI (see Section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.2.105 Based on the information presented above, there is no indication that the potential for behavioural effects associated with underwater noise on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbanks SCI (see Section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.2.106 Based on the information presented above and with respect to the Conservation Objectives for the SAC potentially impacted, the potential for behavioural effects associated with underwater noise on the grey seal feature of this site would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordeekustzone SAC/Noordzeekustzone II SAC (see Section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.8). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

Underwater noise – UXO clearance

Underwater noise from UXO detonation has the potential to cause injury or disturbance to marine mammals

6.5.2.107 There is the potential requirement for underwater UXO clearance prior to construction. Information to inform this assessment is included on the basis that consent for UXO disposal may be required at a later date, however, it does not form part of the current application. The preference would be to avoid UXO wherever possible or remove them from the seabed for disposal to a designated area. However in some cases, this may be considered unsafe and therefore it is necessary to consider the requirement for underwater UXO detonation. UXO clearance for the purposes of this assessment is considered to involve the detonation of the UXO in situ to make it safe to undertake construction works in the surrounding area. UXO detonations underwater are performed for those UXO that are considered unsafe for removal to be disposed of onshore.

6.5.2.108 A detailed UXO survey will be undertaken prior to construction and until that survey takes place the exact number and locations of UXO that may need to be detonated is not known. Therefore, the maximum design scenario for this assessment has been based on an indicative number as informed by recent development work at Hornsea Project One. This assessment has used a combination of the noise modelling carried out for Hornsea Project One and recent studies (von Benda-Beckman *et al*., 2015; BOWL, 2016), in addition tothe charge weights recorded for the UXO cleared. The largest charge weight recorded for Hornsea Project One was approximately 265 kg.

6.5.2.109 Explosive detonations can result in source levels of 272-287 dB SPLpeak re 1µPa@1 m with a frequency spectrum of 2 – 1,000 Hz and the highest energies between 6 - 21 Hz over very rapid durations of 1 – 10 ms (Gotz *et al*. 2009, Richardson *et al*. 1995). The low frequency energy has the potential to travel considerable distances (Parvin *et al*., 2007) and this level of sound can cause injury or even cause death to marine mammals, with the injuries from both the high peak pressures and the initial shock wave that is generated (Genesis, 2011, von Benda-Beckman *et al*., 2017). The main potential effects from UXO detonations to individual animals are: physical injury (from the shock wave); auditory injury (from the acoustic wave) resulting in permanent threshold shift (PTS); and behaviour changes such as disturbance to feeding, mating, resting and breeding. The project will have a UXO specific marine mammal mitigation plan (MMMP), including mitigation measures such as the use of marine mammal observers (MMOs) and acoustic deterrent devices (ADDs).

6.5.2.110 Current advice from the SNCBs is that the NOAA injury thresholds (NMFS, 2016) should be used for assessing the impacts from UXO detonation on marine mammals. However, the suitability of the NOAA criteria for UXO is currently under discussion due to the lack of empirical evidence from UXO detonations using the NOAA metrics, in particular the range dependent characteristics of the peak sounds, and whether current propagation models can accurately predict the range at which these thresholds are reached. Current models have not been validated at ranges relevant to the predictions and there is a possibility that models significantly overestimate ranges for large charge masses (> 25 kg; von Benda-Beckman *et al*., (2015)). Therefore, the areas of the noise contours from the NOAA modelling for Hornsea Project One have been presented alongside the data from von Benda-Beckman *et al*. (2015) with the thresholds based on Southall *et al*. (2007) to provide a range for this assessment.

6.5.2.111 The magnitude of the impact from UXO detonations is related to the source level of the noise generated, which may be affected by a range of factors including: design; composition; age; state of deterioration; orientation; whether it is covered by sediment; and the charge weight of the explosive (Von Benda-Beckman, 2015). Ultimately, only the charge weight of the explosive can be factored into noise modelling and has the greatest influence on the noise modelling source levels.

6.5.2.112 The NOAA modelling for Hornsea Project One did not consider the bathymetry at the site due to uncertainties at the time of modelling of the locations where UXO may be found. The von Benda-Beckman *et al*. (2015) modelling did include bathymetry, with most detonations occurring at approximately 25 – 30 m depth. The most common UXO found within Hornsea Project One had charge sizes of 240 kg, with the total weight of explosive including the detonation charge being 260 kg for which the NOAA PTS range for harbour porpoise is known. The remainder of the Hornsea Project One noise modelling predicted impact ranges for 227 kg and 700 kg charge weights. The von Benda-Beckman *et al*. (2015) modelling incorporated a charge weight of 263 kg which has also been presented here.

UXO Clearance - PTS

6.5.2.113 von Benda-Beckman *et al*., (2015) modelled effect ranges for explosions of up to 1,000 kg charge size, using a model validated out to 2 km by empirical measurements. They found that PTS onset (using a SEL threshold of 179 dB re 1 µPa2s derived from Lucke *et al*., (2009)) ranged between hundreds of metres and just over 10 km for this range of charge masses. Near the surface (where porpoises spend a large proportion of their time (e.g. Teilmann *et al*., (2007)), PTS ranges were lower; just below 5 km for the largest charge masses.

6.5.2.114 von Benda-Beckman *et al*., (2015) reported that for a 263 kg charge weight at 28 m depth, based on values of overpressure levels that would lead to ear trauma from Ketten (2004), PTS for harbour porpoise could extend out to 1.8 km from the source, affecting an area of 10.18 km^2. In the absence of modelled results for other species using the same threshold, this has been assumed to apply also to seals.

6.5.2.115 Beatrice Offshore Wind Farm Limited (BOWL) in the Moray Firth also undertook noise modelling of UXO for a 50 kg explosive using the Southall *et al.* (2007) and NOAA thresholds. The BOWL modelling predicted PTS ranges of 225 m (0.16 km^2) for cetaceans and 764 m (1.83 km^2) for pinnipeds using Southall *et al.* (2007). Based on the NOAA thresholds, PTS ranges were 3.9 km (47.73 km^2) for HF cetaceans, 690 m (2.99 km^2) for LF cetaceans and the same as Southall for MF cetaceans and seals.

6.5.2.116 The noise modelling for Hornsea Project One of a 227 kg charge weight predicted PTS ranges (based on NOAA thresholds) of 8.2 km (211.24 km^2) for harbour porpoise and 1.83 km (10.52 km^2) for pinnipeds. Modelling for a 260 kg UXO was also undertaken for harbour porpoise using the NOAA criteria which gave a range of 8.5 km (226.98 km^2).

6.5.2.117 The number of each species of marine mammal that could potentially be affected by PTS from UXO clearance for the range of charge sizes is presented in Table 6.21. This is quantified by calculating the numbers of animals likely to be within each of the stated impact ranges by multiplying the area of the impact range by the appropriate density estimate. Due to the lack of site specific information at the current stage of the assessment, the variation in the range of impact ranges under consideration, and that fact that this assessment will be updated using more detailed UXO survey data prior to construction, it was deemed appropriate to adopt average uniform densities at the broadest spatial scale in this assessment. The SCANS III densities were therefore used for cetaceans, and the seal usage maps used for seals.

6.5.2.118 The resulting impact is considered to be of negligible to low magnitude, without mitigation, for all species. Once more detailed information is available from site specific surveys and investigations a detailed assessment of the risk of injury and disturbance to marine mammals will be carried out and on the basis of this detailed assessment, a UXO specific MMMP will be developed for Hornsea Three and agreed with the MMO and statutory consultees. This MMMP is likely to include the use of acoustic deterrent devices, in addition to other standard measures. It is anticipated that in compliance with EPS guidance (JNCC, 2010b), this MMMP will reduce the risk of injury to all marine mammal species to negligible.

Table 6.21: Estimate number of marine mammals potentially at risk of PTS during UXO clearance

Impact	Receptor	Impact area (km^2)	Estimated number in impact area	% of reference population
263 kg charge weight von Benda-Beckman *et al.* (2015)	Harbour porpoise	10.18	29	0.003
	Harbour seal		0	0
	Grey seal		<1	<0.0001
50 kg charge weight BOWL (2016) modelling of Southall *et al.* (2007)	Harbour porpoise	0.16	<1	<0.0001
	Harbour seal	1.83	0	0
	Grey seal		<1	<0.0001
50 kg charge weight BOWL (2016) modelling of NOAA	Harbour porpoise	47.73	42	0.012
260 kg charge weight Hornsea Project One modelling using NOAA	Harbour porpoise	226.98	200	0.0578
	Harbour seal	10.52	<1	<0.0001
	Grey seal	10.52	<1	<0.0001

UXO Clearance - Disturbance

6.5.2.119 Behavioural responses to noise are highly variable and are dependent on a variety of internal and external factors. Internal factors include past experience, individual hearing sensitivity, activity patterns, motivational and behavioural state at the time of exposure. Demographic factors such as age, sex and presence of dependent offspring can also have an influence. Environmental factors include the habitat characteristics, presence of food, predators, proximity to shoreline or other features. Responses themselves can also be highly variable, from small changes in behaviour such as longer intervals between surfacing (Richardson 1995) or a cessation in vocalisation (Watkins 1986) to more dramatic escape responses (Götz and Janik 2016).

6.5.2.120 This variability makes it challenging to predict the likelihood of responses to underwater noise from UXO detonations. Even where empirical data exist on responses of animals in one particular environment, the context related variability described above makes it difficult to extrapolate from one study to a new situation.

6.5.2.121 Natural England and JNCC advise that a buffer of 26 km around the source location is used to determine the impact area from UXO clearance with respect to disturbance of harbour porpoise in the Southern North Sea cSAC. Hornsea Three array area is outside the cSAC, however the cable corridor, where UXO detonations may still be required, passes through the cSAC and therefore the use of the 26 km area has been used for this assessment.

6.5.2.122 A UXO specific MMMP will be employed for Hornsea Three UXO detonation, however mitigation is highly unlikely on the basis of current understanding to mitigate the full area for disturbance. Therefore, the assessment and estimates of the number each species that may be affected as presented in Table 6.22 is based on a no mitigation scenario.

6.5.2.123 Each detonation will result in a single pulse of sound and based on data gathered on Hornsea Project One, only a small number of UXO, a total of 23, are anticipated to require detonation. Therefore animals will experience very short lived periods of disturbance on an estimated 23 occasions.

6.5.2.124 The use of explosives over such a short period of time is considered to have a low likelihood of leading to disturbance. In essence, it has been assumed that a worst case of up to 23 discrete UXO clearance disturbance events, extending up to 2,124km^2 (based on 26km radius) across the SNS cSAC (up to 7.86% of the summer extents) could occur. Clearly such one-off disturbance events are well below the 20% threshold deemed significant for any given day. Should the area of disturbance be averaged out over the 6 month summer season, assuming a single explosion per day for 23 days (which is similarly precautionary, since multiple detonations per day would be anticipated), then the effect over the season equates to 0.99%, well below the 10% threshold across the 6 month summer season. In reality the average over the season will be far less than this, as it is likely that multiple detonations would take place within a day and that not all detonations would fall within (or wholly within) the cSAC. These conclusions are therefore, considered extremely precautionary.

Table 6.22: Estimate number of marine mammals potentially at risk of disturbance during UXO clearance

Impact	Receptor	Estimated number in impact area	% of reference population	Magnitude
Disturbance area of 2124 km^2	Harbour porpoise	1869	0.5	Low
	Grey seal	98	0.2	Low
	Harbour seal	3	0.04	Low

Conclusions

The Wash and North Norfolk Coast SAC

6.5.2.125 Based on the information presented above there is no indication that injurous or behavioural effects associated with underwater noise generated by UXO clearance on the harbour seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Wash and North Norfolk SAC (see Section 6.2.2). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.5.2.126 Based on the information presented above there is no indication that injurious or behavioural effects associated with underwater noise generated by UXO clearance on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Humber Estuary SAC/Ramsar (see Section 6.2.3). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.2.127 Based on the information presented above there is no indication that injurious or behavioural effects associated with underwater noise generated by UXO clearance on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see Section 6.2.4). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.4). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC

6.5.2.128 Based on the information presented above, there is no indication that the potential for injurious or behavioural effects associated with underwater noise generated by UXO clearance on the harbour porpoise qualifying feature of this site would lead to a reduction in the viability of the species or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained, a Conservation Objective of the Southern North Sea cSAC (see Section 6.2.5). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.5.2.129 Based on the information presented above, there is no indication that the potential for injurious or behavioural effects associated with underwater noise generated by UXO clearance on the harbour seal and grey seal features of this SCI would lead to a reduction in the extent or quality of the habitat in order to maintain the populations, a Conservation Objective of the Klaverbank SCI (see Section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.2.130 Based on the information presented above, there is no indication that the potential for injurious or behavioural effects associated with underwater noise generated by UXO clearance on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbank SCI (see Section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see Section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.2.131 Based on the information presented above and with respect to the Conservation Objectives for the SAC potentially impacted, the potential for injurious or behavioural effects associated with underwater noise generated by UXO clearance on the grey seal feature of this site would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordzeekustzone SAC/ Noordzeekustzone II SCI (see Section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

Increased vessel traffic: noise and collision risk

6.5.2.132 Increased vessel movement has the potential to result in a range of impacts on marine mammals, including:

- Masking of vocalisations or changes in vocalisation rate;
- Avoidance behaviour or displacement; and
- Injury or death due to collision with vessels.

6.5.2.133 The magnitude of impact from vessel noise, with associated disturbance, or risk of collision with marine mammals is likely to be affected by vessel type, speed, and ambient noise levels. Laist *et al.* (2001) predicted the most severe injuries from collision with vessels when travelling at over 14 knots.

6.5.2.134 Disturbance from vessel noise is likely to occur only where increased noise from vessel movements associated with the construction of Hornsea Three is greater than the background ambient noise level. The Greater Wash is a relatively busy shipping area, therefore background noise levels are likely to be high.

6.5.2.135 Marine mammals may be more vulnerable to collision risk if they are not able to detect the approach of a vessel. For example, sound produced during piling operations may mask the presence of vessels, leading to reduced detection and avoidance by marine mammals which could lead to increased potential for vessel strikes to occur.

6.5.2.136 Though impacts associated with increased vessel movement have the potential to occur throughout the potential eight year construction period, these are likely to occur in phases throughout this period depending on construction build out programme. Current maximum design scenario would be all construction vessel movements spread throughout two construction phases (approximately 2.5 years per phase) within the eight year construction period, with a three year gap between similar construction activities (Table 4.2). It has been assumed that masking and potential for avoidance behaviour may occur several kilometres from the noise source for all species.

6.5.2.137 Comparative analysis undertaken by Subacoustech Ltd (Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report) of potential noise sources during construction ranked noise from construction vessels as least noisy when compared to other construction activities. Vessel movements from large vessels and medium vessels are predicted to produce noise at 171 dB re 1 μPa @ 1 m (RMS) and 164 dB re 1 μPa @ 1 m (RMS) respectively. Although the frequency components of the noise produced by vessels are different to those from piling, and the noise is a continuous sound as opposed to impulsive, marine mammals are likely to respond first and foremost to the greater noise levels produced by piling. Marine mammals therefore have a greater potential to be impacted by increased vessel movements during periods when piling is not taking place. During the period of piling operations it is therefore considered unlikely that vessel noise will impact marine mammal Annex II features at anything other than immediate proximity, should animals be in the area. Individuals have the potential to be impacted by increased vessel movements during periods when piling is not taking place.

6.5.2.138 Table 4.2 details the type of construction vessels predicted to be used, and the number of vessel movements (return trips) associated with the construction of Hornsea Three. Assuming a maximum design scenario, where vessel movements are spread over two construction phases during the eight year offshore construction period, this would equate to a potential increase in vessel movements of approximately 5,237 per construction phase, or 2,095 per year, 145 per month or 5.7 per day during each 2.5 year construction phase within the eight year offshore construction period with up to 8 vessels in a 5 km^2 area at any one time. These numbers are based upon an assumption that the same (maximum) number of vessel transits would occur to/from port for each foundation installed. It is highly likely, however, that a proportion of vessels will be stationary or slow moving throughout construction activities for significant periods of time, particularly smaller vessels, therefore the actual increase in vessel traffic moving around the site and to/from the port to the site will occur over short periods of offshore construction activity. The likelihood is therefore that actual increased vessel movements within offshore construction periods will be lower than stated above. Vessel operators will follow the code of conduct (Table 4.6) to avoid any abrupt changes in speed and therefore increasing their predictability of movement to marine mammals.

6.5.2.139 The current level of vessel activity passing through the Hornsea Three array area, plus a 10 NM buffer (Hornsea Three Array Area Shipping and Navigation Study Area; Environmental Statement volume 2, chapter 7: Shipping and Navigation, Section 1.8.2) is on average 19.6 vessels per day (Environmental Statement volume 2, chapter 7: Shipping and Navigation). The future baseline (within 20 years of current baseline and not vessel traffic associated with Hornsea Three) is expected to show an increase in vessel activity within the same study area of 10% (Environmental Statement volume 2, chapter 7: Shipping and Navigation, Section 1.1.6).

6.5.2.140 Vessel traffic associated with Hornsea Three has the potential to lead to an increase in vessel movements within the Hornsea Three shipping and navigation study area. This area does not equate exactly to either the Hornsea Three marine mammal study area or the regional marine mammal study area; however, as a conservative assumption it has been taken to be more similar to the Hornsea Three marine mammal study area. This increase in vessel movement could lead to an increase in interactions between marine mammals and vessels during offshore construction.

6.5.2.141 A maximum of four turbine installation vessels, 24 support vessels, and 12 transport vessels are predicted to be on site in Hornsea Three at any one time. Impacts are predicted to be reversible except in the case of a vessel strike in which case the impact would be irreversible (i.e. could lead to mortality). However due to the likelihood of animals showing some degree of habituation to vessel noise, the potential for more than a minor shift from baseline is considered unlikely.

6.5.2.142 The impact is predicted to be of local spatial extent, medium term duration (eight year construction period), intermittent, and both reversible (in the case of increased noise), and irreversible (in the case of a collision).

6.5.2.143 The main source of noise from vessels comes from propeller cavitation and vessel noise is known to increase with speed and loading for all vessel sizes (Senior *et al.*, 2008). Reactions of marine mammals to vessel noise are often linked to changes in the engine and propeller speed (Richardson *et al.*, 1995).

6.5.2.144 Studies have shown that unless the received vocalisation and masking noise come from the same direction, masking is unlikely to be at significant levels (Richardson *et al.*, 1995). This is because directional hearing, coupled with the strong directional nature of echolocation pulses, is an important adaptation in echolocating marine mammals.

6.5.2.145 Marine mammals can both be attracted to, and avoid, vessels. Harbour porpoise are particularly sensitive to high frequency noise and are more likely to avoid vessels; Heinanen and Skov (2015) identified that the occurrence of harbour porpoise declines significantly when the number of vessels in a 5 km^2 area exceeds 80 in one day. With an average of 19.6 vessels per day as a baseline, with a maximum increase of 6 vessels per day, in an area considerably larger than 5 km^2, vessel density will remain well below this threshold level for harbour porpoises. As a maximum design scenario, with commissioning of a turbine occurring within the same 5 km^2 as piling, up to 8 vessels may be in a 5 km^2 area during construction.

6.5.2.146 Hastie *et al.* 2003 observed changes in surface behaviour, and Palka and Hammond (2001) reported animals avoiding vessels. They also suggest that vessel presence, not just vessel noise, resulted in disturbance. There is however likely to be rapid recovery from disturbance from vessel presence and vessel noise, as they recorded little pre-emptive disturbance or recovery time following disturbance. There is evidence of habituation to boat traffic, particularly in relation to larger vessel types (Sini *et al.,* 2005). Lusseau *et al*. 2011 (Scottish Natural Heritage (SNH) commissioned report), undertook a modelling study which predicted that increased vessel movements associated with offshore wind development in the Moray Firth did not have a negative effect on the local population of bottlenose dolphin, although it did note that foraging may be disrupted by the disturbance from vessels.

6.5.2.147 Richardson *et al.* (2005) reported avoidance behaviour or alert reactions in harbour seal when vessels approach within 100 m of a haul-out (Richardson *et al.*, 2005); however, seals are known to be curious and have been recorded approaching tour boats that regularly visit an area, and may habituate to sounds from tour vessels (Bonner, 1982).

6.5.2.148 Studies have reported that noise levels from large vessels have not caused damage to marine mammal hearing ability, though local disturbance to marine mammals may result (Malme *et al.*, 1989, Richardson *et al.*, 1995). This however will be dependent on individual hearing ranges and background noise levels within the locality.

6.5.2.149 Vessel strikes are known to be a cause of mortality in marine mammals (Pace *et al.*, 2006), but it is possible that mortality from vessel strikes is under-recorded (David, 2006). Laist *et al.* (2001) reported that collisions between vessels and large whales tended to lead to death, but non-lethal collision has also been reported by Van Waerbeek *et al.* (2007). Therefore collisions between vessels and marine mammals are not necessarily lethal on all occasions

6.5.2.150 It is considered that there is a high likelihood of avoidance from both increased vessel noise and collision risk, with both a high potential for recovery (< 1 year) for increased noise, and medium potential for recovery for collision risk (reflecting the low likelihood of collision and potential for non-lethal collision to occur). While the recovery from vessel disturbance is dependent on the number of vessels present during the operational phase, operational phase vessels are likely to be smaller and consequently disturbance and collision risk are considered to be reduced. Between the construction phases, vessel presence will reduce, with fewer operational vessels required than the maximum assessed (fewer structures will require proportionally fewer operational visits) and during the second phase of construction, it is likely that vessels may undertake joint construction and operational activities while on site, reducing the combined vessel movements required.

<u>Conclusions</u>

The Wash and North Norfolk Coast SAC

6.5.2.151 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the harbour seal feature within this SAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated, a Conservation Objective of the Wash and North Norfolk Coast SAC (see section 6.2.2). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.5.2.152 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the grey seal feature within this SAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated, a Conservation Objective of the Humber Estuary SAC/Ramsar (see section 6.2.3). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.2.153 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the grey seal feature within this SAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see section 6.2.34). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.34). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC

6.5.2.154 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would lead to a reduction in the viability of the harbour porpoise feature or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained, Conservation Objectives of the Southern North Sea cSAC (see section 6.2.5). Furthermore, due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the distribution of the feature within this cSAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated. Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.5.2.155 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a reduction in the extent or quality of the habitat in order to maintain the feature populations, a Conservation Objective of the Klaverbank SCI (see section 6.2.6). Furthermore, due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the population or the distribution of the features within this SCI in the long term and subsequently no adverse effect on the population or distribution of this qualifying seal features is anticipated. Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.2.156 Based on the information presented above, there is no indication that that effects associated with increased vessel traffic on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbank SCI (see section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.2.157 Based on the information presented above, effects associated with increased vessel traffic would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordzeekustzone SAC/ Noordzeekustzone II SCI (see section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.8). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

Accidental pollution events

6.5.2.158 The potential sources of pollution during the construction phase include vessel movements, use of drilling muds and storage of chemicals including lubricants, coolant, hydraulic oil and fuel on offshore platforms (Table 4.2). The magnitude of the impact is dependent on the nature of the pollution incident but the Strategic Environmental Assessment (SEA) carried out by DECC (2011) recognised that, "renewable energy developments have a generally limited potential for accidental loss of containment of hydrocarbons and chemicals, due to the relatively small inventories contained on the installations (principally hydraulic, gearbox and other lubricating oils, depending on the type of installation)". Any spill or leak within the offshore regions of Hornsea Three would be immediately diluted and rapidly dispersed.

6.5.2.159 Throughout construction there will be the requirement to store fuel offshore for the purposes of refuelling crew transfer vessels (CTVs) and/or helicopters with fuel storage assumed to be placed on offshore accommodation platforms (see Table 4.2). An impact upon marine mammal features would only be realised if an incident occurs where the fuel is accidentally released.

6.5.2.160 The historical frequency of pollution events in the southern North Sea is low considering the density of existing marine traffic in the area. As part of the project design, an MPCP will be developed (Table 4.6) which will include measures to follow published guidelines and best working practice for the prevention of pollution events. Therefore accidental release of contaminants will be strictly controlled and an emergency plan will also be put in place in the unlikely event of an incident. Provided that the MPCP is followed, there are unlikely to be any pollution events, and those that do occur would be very small scale and short lived, due to rapid dispersal and dilution. Additionally, it is likely that the noise and vessel presence associated with the activities will result in displacement of marine mammals from the area where a pollution release could occur.

6.5.2.161 Release of contaminants into the water column may lead to direct impacts on marine mammals through ingestion, inhalation or absorption through the skin, and potentially longer-term indirect impacts from bioaccumulation in the food chain. Seals are likely to be more vulnerable to the effects of surface pollution than cetaceans because of their reliance on terrestrial sites for resting, moulting and pupping. Of particular concern would be the contamination of the coastal waters of North Norfolk and Lincolnshire, where grey and harbour seal haul-out in large numbers. Seal pups entering the water would be particularly vulnerable as oil residues can reduce the thermal properties of neonate animals, increasing their susceptibility to hypothermia (Jenssen, 1996).

6.5.2.162 The release of oils is a serious concern for all marine mammals as the inhalation of toxic, volatile compounds could lead to mortality.

6.5.2.163 Whilst seals and cetaceans are highly mobile, and capable of detecting surface slicks in open water, the more extensive the slick, the more likely it is that an animal will surface within it (Geraci and St. Aubin, 1990).

6.5.2.164 Marine mammals are likely to avoid any minor events and therefore are of low vulnerability with the potential for high recoverability.

Conclusions

The Wash and North Norfolk Coast SAC

6.5.2.165 Based on the information presented above there is no indication that effects associated with accidental pollution events would lead to a reduction in the extent or structure and function of the habitats of the qualifying species or the supporting processes on which this species rely, a conservation objective of the Wash and North Norfolk Coast SAC (see section 6.2.2). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.5.2.166 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the extent or structure and function of the habitats of the qualifying species or the supporting processes on which this species rely, a Conservation Objective of the Humber Estuary SAC/Ramsar (see section 6.2.3). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.2.167 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the extent or structure and function of the habitats of the qualifying species or the supporting processes on which this species rely, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see section 6.2.34). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.34). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC

6.5.2.168 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the viability of the harbour porpoise feature or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained, a Conservation Objective of the Southerno North Sea cSAC (see section 6.2.5). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.5.2.169 Based on the information presented above, there is no indication that effects associated with accidental pollution events would result in a reduction in the extent or quality of the habitat in order to maintain the feature populations, a Conservation Objective of the Klaverbank SCI (see section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.2.170 Based on the information presented above, there is no indication that that effects associated with accidental pollution events on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbank SCI (see section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.2.171 Based on the information presented above, effects associated with accidental pollution events would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordzeekustzone SAC/ Noordzeekustzone II SCI (see section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.8). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

6.5.3 Potential impacts - operation and maintenance

6.5.3.1 The impacts of the offshore operation and maintenance of Hornsea Three have been assessed on marine mammals. The potential impacts arising from the operation and maintenance of Hornsea Three are listed in Table 4.2 along with the maximum design scenario against which each operation and maintenance phase impact has been assessed.

Increased vessel traffic and collision risk

6.5.3.2 The potential impacts of increased vessel movement have been detailed above and have not been reiterated here.

6.5.3.3 In summary, the potential impacts of increased vessel movement during the operation and maintenance phase of Hornsea Three are:

- Masking of vocalisations or changes in vocalisation rate;
- Avoidance behaviour or displacement; and
- Injury or death due to collision with vessels.

6.5.3.4 Table 4.1 details the type and number of operation and maintenance vessels predicted to be used over the 35 year duration of the operational lifetime of Hornsea Three.

6.5.3.5 The current level of vessel activity passing through the Hornsea Three marine mammal study area is 12,775 vessel movements per year. Over the expected 35 year operation and maintenance phase of Hornsea Three, there is expected to be an increase of 2,822 vessel movements (return trips) per year. There is therefore a potential for an increase in vessel movement and therefore interactions between marine mammals and operation and maintenance traffic throughout this period.

6.5.3.6 A maximum of four offshore supply vessels and up to 20 CTVs are expected to be on site at Hornsea Three at any one time. Impacts are predicted to be reversible except in the case of a strike in which case the impact would be irreversible (i.e. could lead to mortality). However due to the likelihood of animals showing some degree of habituation to vessel noise, the potential for more than a minor shift from baseline is considered unlikely.

6.5.3.7 The impact is predicted to be of local spatial extent, long term duration (35 year operational and maintenance period), intermittent, and both reversible (in the case of vessel noise), and irreversible (in the case of a collision).

6.5.3.8 It is considered that there is a high likelihood of avoidance from both increased vessel noise and collision risk, with both a high potential for recovery (< 1 year) for increased noise, and medium potential for recovery for collision risk reflecting the low likelihood of collision and potential for non-lethal collision to occur).

Conclusions

The Wash and North Norfolk Coast SAC

6.5.3.9 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the harbour seal feature within this SAC in the long term (a Conservation Objective of the Wash and North Norfolk Coast SAC, see section 6.2.2) and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated. Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the grey seal feature within this SAC in the long term (a Conservation Objective of the Humber Estuary SAC/Ramsar, see section 6.2.3) and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated. Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.3.10 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the grey seal feature within this SAC in the long term, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see section 6.2.34). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.34). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC

6.5.3.11 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would lead to a reduction in the viability of the harbour porpoise feature or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained, a Conservation Objective of the Sotuhern North Sea cSAC (see section 6.2.5). Furthermore, due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the distribution of the feature within this cSAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated. Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.5.3.12 Based on the information presented above, there is no indication that effects associated with increased vessel traffic would result in a reduction in the extent or quality of the habitat in order to maintain the feature populations, a Conservation objective of the Klaverbank SCI (see section 6.2.6). Furthermore, due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the population or the distribution of the features within this SCI in the long term. Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.3.13 Based on the information presented above, there is no indication that that effects associated with increased vessel traffic on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbank SCI (see section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.3.14 Based on the information presented above, effects associated with increased vessel traffic would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordzeekustzone SAC/ Noordzeekustzone II SCI (see section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.8). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

Accidental pollution events

6.5.3.15 Accidental pollution released during operation and maintenance (including maintenance activities, vessels, machinery and offshore fuel storage tanks) may lead to release of contaminants into the marine environment and subsequently result in potential effects on marine mammals.

6.5.3.16 The potential impacts of accidental pollution on marine mammals have been outlined above and have not been re-iterated here.

6.5.3.17 Each turbine within the Hornsea Three array area will contain components which will require lubricants and hydraulic oils in order to operate; maximum quantities are provided in Table 4.2 and Environmental Statement volume 1, chapter 3: Project Description. The nacelle, tower and hub of the turbines will be designed to retain any leaks should they occur.

6.5.3.18 An MPCP will be produced and implemented to cover the operation and maintenance phase of Hornsea Three (Table 4.6). This MPCP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details.

6.5.3.19 Any potential impact is predicted to be of local to regional spatial extent, short term duration, intermittent and reversible. Marine mammals are likely to be able to avoid any minor/spatially limited events.

<u>Conclusions</u>

The Wash and North Norfolk Coast SAC

6.5.3.20 Based on the information presented above there is no indication that effects associated with accidental pollution events would lead to a reduction in the extent or structure and function of the habitats of the qualifying species or the supporting processes on which this species rely, a Conservation Objective of the Wash and North Norfolk Coast SAC (see section 6.2.2). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.2). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.5.3.21 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the extent or structure and function of the habitats of the qualifying species or the supporting processes on which this species rely, a Conservation Objective of the Humber Estuary SAC/Ramsar (see section 6.2.3). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.3). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.5.3.22 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the extent or structure and function of the habitats of the qualifying species or the supporting processes on which this species rely, a Conservation Objective of the Berwickshire and North Northumberland Coast SAC (see section 6.2.34). Nor is there any indication that this impact would adversely affect the other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.34). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC

6.5.3.23 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the viability or distribution of the harbour porpoise feature or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained, a Conservation Objective for the Southern North Sea cSAC (see section 6.2.5). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.5). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.5.3.24 Based on the information presented above, there is no indication that effects associated with accidental pollution events would result in a reduction in the extent or quality of the habitat in order to maintain the feature populations, a Conservation Objective of the Klaverbank SCI (see section 6.2.6). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.6). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.5.3.25 Based on the information presented above, there is no indication that that effects associated with accidental pollution events on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained, a Conservation Objective of the Doggersbank SCI (see section 6.2.7). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.7). On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.5.3.26 Based on the information presented above, effects associated with accidental pollution events would not prevent the extent and quality of habitat in order to maintain the population from being maintained, a Conservation Objective of the Noordzeekustzone SAC/ Noordzeekustzone II SCI (see section 6.2.8). Nor is there any indication that this impact would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site (see section 6.2.8). On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

6.6 In-combination assessment methodology

6.6.1 Screening of other projects and plans

6.6.1.1 The in-combination assessment considers the impact associated with Hornsea Three together with other projects and plans. The projects and plans selected as relevant to the assessments for the RIAA were initially identified from the results of a screening exercise undertaken for the Environmental Statement (see Environmental Statement volume 4, annex 5.2: Cumulative Effects Screening Matrix and Environmental Statement volume 4, annex 5.3: Location of Schemes) and then each project on the CEA long list has been considered on a case by case basis for screening in or out of this RIAA upon data confidence, effect-feature pathways and the spatial/temporal scales involved. Section 4.4 details the approach to the in-combination assessment.

6.6.1.2 The projects considered in this in-combination assessment are those activities which have not been included in the baseline assessment for marine mammals, and where there was the potential for impacts to arise during the construction, operation and maintenance, or decommissioning phase of Hornsea Three. These projects include:

- Offshore energy developments;
- Cables and pipelines;
- Marine aggregates;
- Military and aviation; and
- Coastal developments (i.e. ports and harbours).

6.6.1.3 The plans and projects screened in have then been considered on a case by case basis to determine whether the potential for an in-combination effect exists (Table 6.23).

6.6.1.4 During the initial screening exercise for marine mammals, projects were considered over the whole of the North Sea MU (Figure 6.3) as the largest in-combination study area. Further to this, for each impact the extent of the cumulative assessment was refined depending on the scale of the potential impact. For subsea noise arising from piling and disturbance from vessel movements, the effects may be far reaching and therefore were assessed over the largest area for each species.

6.6.1.5 Marine aggregate and dredging projects have been screened out as a potential direct impact on marine mammals as direct effects are considered likely to be localised and any uplift in vessel movements very small.

6.6.1.6 Information provided in Environmental Statement volume 4, annex 5.1: Cumulative Effects Screening Matrix on oil and gas projects, shipping and navigation, and commercial fisheries, demonstrated that there were no additional impacts likely to occur as the impacts of these activities had been included as part of the baseline assessment on marine mammals. No further consideration in the in-combination assessment is given to these projects.

6.6.1.7 Noise impacts arising from cable and pipeline installation have been screened out on the basis that these are considered to be highly localised, short term, and of negligible magnitude. In addition, all oil and gas activities listed in the CEA long list are currently operational and therefore were considered to be part of the baseline and screened out for in-combination impacts of subsea noise.

6.6.1.8 Maximum design scenario for ports and harbours assumes an increase in subsea noise arising from projects that involve pile-driving activity during construction. Projects have been screened out where there is a very short piling duration (less than one month), or very few piles to be installed (less than ten), and/or the project is over 200 km distance from the nearest point in Hornsea Three.

6.6.1.9 With regard to increased vessel traffic, cables and pipelines are included if the operational phase has not already commenced (i.e. not part of the baseline).

6.6.1.10 Increased vessel activity from dredging activities and Dutch military activities have been screened out on the basis that the uplift in vessel numbers is predicted to be very small and vessel movements localised.

6.6.1.11 For ports and harbours, vessel traffic during construction phase is screened out on the basis that the uplift in vessel numbers is predicted to be very small and/or vessel movements highly localised. During operation, the impact of vessel traffic is screened in where there is an extension to an existing facility or an installation of a new facility resulting in additional berths for more than 25 vessels, therefore leading to a potential increase in vessel traffic.

6.6.1.12 The scale over which the in-combination effects have been assessed for each marine mammal species is based upon the criteria of the screening exercise described above, and within the relevant MU for each species, as discussed and agreed with the Marine Mammal EWG.

6.6.1.13 In undertaking the CEA for Hornsea Three, it is important to bear in mind that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Hornsea Three. For example, relevant projects and plans that are already under construction are likely to contribute to an in-combination impact with Hornsea Three (providing effect or spatial pathways exist), whereas projects and plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors. For this reason, all relevant projects and plans considered in-combination alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the CEA to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each Tier in the decision making process when considering the potential in-combination impact associated with Hornsea Three (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2). An explanation of each tier is included below:

- Tier 1: Hornsea Three considered alongside other project/plans currently under construction and/or those with a legally secure consent (i.e. projects that are not subject to an ongoing judicial review process) that have been awarded a CFD but have not yet been implemented and/or those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact;
- Tier 2: All projects/plans considered in Tier 1, as well as those project/plans that have a legally secure consent but have no CFD and/or submitted but not yet determined and/or those with a non-legally secure consent (i.e. projects that are subject to an ongoing judicial review process); and
- Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects and the adopted development plan including supplementary planning documents are the most relevant sources of information, along with information from the relevant planning authorities regarding planned major works being consulted upon, but not yet the subject of a consent application). Specifically, this Tier includes all projects where the developer has advised PINS in writing that they intend to submit an application in the future, those projects where a Scoping Report is available and/or those projects which have published a Preliminary Environmental Information Report (PEIR).

6.6.1.14 The specific projects scoped into this assessment and the Tiers into which these projects have been allocated, are outlined in Table 6.23 and illustrated in Figure 6.19 and Figure 6.20. The projects included as operational in this assessment have been commissioned since the baseline studies for this project were undertaken and as such were excluded from the baseline assessment.

6.6.1.15 As with the alone assessments, based on the fact that all the European sites screened in for assessment (Table 6.1) are located with the same North Sea MU (see Figure 6.3 and Figure 6.5) and considering the approach agreed with the EWG and described in the JNCC Workshop Report (2016) that it is not, currently, appropriate or practical to maintain a given marine mammal abundance within a site because of the natural variability in numbers and therefore, as long as the abundance within the MU is maintained and the site Conservation Objectives are met, Favourable Conservation Status (FCS) of the species will be maintained, the following assessments will apply to all screened in sites and associated qualifying marine mammal features described in Table 6.1.

6.6.1.16 Therefore, the assessments in this section have not been broken down by European site so as to avoid unnecessary repetition, however; if necessary, consideration has been given to assessments should variation in the detailed Conservation Objectives materially alter the assessment and conclusions have been presented for each European site assessed.

6.6.2 Maximum design scenario

6.6.2.1 The maximum design scenarios identified in Table 6.24 have been selected as those having the potential to result in the greatest effect on Annex II marine mammal qualifying features. The in-combination effects presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (Environmental Statement volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, in order to inform a 'maximum design scenario'. Effects of greater significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

6.6.3 In-combination screening conclusions

6.6.3.1 All plans and projects within the wider North Sea MU have been considered where in-combination effect pathways have been identified as these have the potential to impact on the abundance within the MU, and subsequently on the FCS of the species of the designated sites being assessed.

6.6.3.2 The following impacts have not been considered in this assessment due to the highly localised nature of some of the impacts and because no in-combination impact pathways have been identified or, where the potential impact has been assessed as negligible for Hornsea Three offshore wind farm alone. These impacts are:

- Construction/decommissioning phase:
  - Accidental pollution released during construction (including construction activities, vessels, machinery and offshore fuel storage tanks) may lead to release of contaminants into the marine environment and subsequently result in potential effects on marine mammals
- Operation and maintenance phase:
  - Accidental pollution released during operation and maintenance (including maintenance activities, vessels, machinery and offshore fuel storage tanks) may lead to release of contaminants into the marine environment and subsequently result in potential effects on marine mammals.

6.6.3.3 It should be noted that the in-combination assessment has been undertaken on the basis of the most recent, publicly available information for the other projects, plans and activities. The level of impact on marine mammal would likely be reduced from those presented here.

6.6.3.4 For projects in Tier 2 the level of detail available is sometimes limited at this stage and therefore the assessments presented for this Tier are semi-quantitative. There were no projects in Tier 3 which provided sufficient information to allow a robust assessment of impacts on marine mammals. Therefore, a qualititative approach has been taken for Tier 3 projects.

6.6.3.5 The following potential impacts have been assessed in-combination with other plans and projects:

- Underwater noise from foundation piling and other construction activities (e.g. drilling of piles) within the Hornsea Three with underwater noise arising during construction of other projects has the potential to cause injury or disturbance to marine mammals; and
- Increased traffic during construction, operation or decommissioning of Hornsea Three may result in an increase in disturbance, collision risk or injury to marine mammals during construction, operation or decommissioning of other projects.

Table 6.23: List of other projects and plans considered within the in-combination assessment.

Tier	Phase	Project/Plan	Distance from Hornsea Three array (km) (nearest point)	Distance from Hornsea Three offshore cable corridor (km) (nearest point)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
1	***Offshore wind farms***							
	Under construction	Dudgeon	87	11	168 turbines under construction	2015 to 2017	No	Yes
		Race Bank	114	28	206 turbines consented, 91 constructed.	2015 to 2017	No	Yes
		Hornsea Project One	7	7	332 turbines assessed in the Environmental Statement (although 240 turbines actually consented), of which 174 turbines to be constructed.	2017 to 2019	No	Yes
		Beatrice	566	581	84 turbines under construction	2017 to 2018	No	Yes
		Galloper	119	79	56 turbines under construction	2017	No	Yes
		MEG Offshore I (now Merkur Offshore Wind Farm)	247	260	400 MW turbines under construction	2017 to 2019	No	Yes
		Nordergruende	353	368	18 6.15 MW under construction	2017 to 2018	No	Yes
		Sandbank 24	298	317	72 4 MW turbines under construction	2017	No	Yes
	Consented	Aberdeen demonstration	444	461	Up to 100 MW with no more than 11 turbines	2017 - 2018	No	Yes
		Blyth demo	258	273	Up to 15 turbines consented, five constructed	2017	No	Yes
		East Anglia One	152	106	102 x 7 MW turbines consented	2018	No	Yes
		Hornsea Project Two	7	8	360 turbines assessed in the Environmental Statement. Up to 300 turbines consented	2020 to 2022	Yes	Yes
		Kincardine	422	438	Eight 6 MW turbines consented	2018 to 2019	No	Yes
		Triton Knoll	100	44	Up to 288 turbines consented	2017 to 2021	Yes	Yes
		Hywind Scotland Pilot Park	438	455	Five 6 MW turbines consented	2017	No	Yes
		Moray East (previously Moray Offshore Renewables Ltd Eastern Development Area)	548	565	Up to186 6 to 8 MW turbines consented (revised PD = 137 x 8.1-15 MW turbines)	2022 to 2023	Yes	Yes
		Neart na Gaoithe	372	388	Up to 64 turbines	2020 to 2021	Yes	Yes
		Inch Cape	384	401	Up to 110 turbines	2020 to 2021	Yes	Yes
		SeaGreen Phase 1 (Alpha, Bravo)	367	384	Up to 75 turbines per sub-project	2022 to 2024	Yes	Yes
		Norther (Belgium)	236	163	44 8 MW turbines consented	2017 to 2018	No	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three array (km) (nearest point)	Distance from Hornsea Three offshore cable corridor (km) (nearest point)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
		Rentel Area A (Belgium)	231	155	42 7.35 MW turbines consented	2017 to 2018	No	Yes
		Seastar (Belgium)	225	149	42 6 MW turbines consented	2017 to 2018	No	Yes
		Borkum Riffgrund 2 (Germany)	241	225	56 8 MW turbines consented	2018 to 2019	No	Yes
		Trianel Windpark Borkum (Germany)	242	255	32 6.15 MW turbines consented	2017	No	Yes
		Deutsche Bucht Offshore Wind Farm (Germany)	203	217	30 8 MW turbines consented	2017 to 2019	No	Yes
		Borssele 1 and 2 (Netherlands)	216	181	Up to 127 turbines consented (6 to 10 MW)	2017 to 2020	No	Yes
		Borssele 3 and 4 (Netherlands)	217	175	Up to 123 turbines consented (6 to 10 MW)	2018 to 2021	Yes	Yes
		Horns Rev 3 (Denmark)	373	394	49 8.3 MW turbines consented	2017 to 2018	No	Yes
		Nissum Bredning (Denmark)	461	485	4 7 MW turbines	2017 to 2018	No	Yes
	Aggregate extraction and disposal sites							
	Operational (with on-going effects)	Humber 3 – 484	43	0	Operational	N/A	N/A	Yes
		Inner Dowsing - 481/1-2	126	41	Operational	N/A	N/A	Yes
		Inner Dowsing - 481/1-2	127	38	Operational	N/A	N/A	Yes
		Inner Dowsing - 481/1-2	126	41	Operational	N/A	N/A	Yes
		Inner Dowsing - 481/1-2	127	38	Operational	N/A	N/A	Yes
		Outer Dowsing - 515/1-2	102	41	Operational	N/A	N/A	Yes
		Outer Dowsing - 515/1-2	88	38	Operational	N/A	N/A	Yes
		Humber 4 – 490	19	13	Operational	N/A	N/A	Yes
		Humber 7 – 491	4	0	Operational	N/A	N/A	Yes
		Inner Dowsing - 481	125	38	Operational	N/A	N/A	Yes
		Inner Dowsing - 481	125	38	Operational	N/A	N/A	Yes
		Humber (disposal site)	77	32	Operational	N/A	N/A	Yes
		West of Inner Dowsing Bank	131	48	Application for operation sought up to December 2029	N/A	N/A	Yes
	Cables and pipelines							
	Pre-commission	PL2236 – Mimas to Saturn	33	22	33 inch Pre-commission CHEMICAL pipeline operated by CONOCOPHILLIPS	2017 to 2018	No	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three array (km) (nearest point)	Distance from Hornsea Three offshore cable corridor (km) (nearest point)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
		PL2237 - Saturn to Mimas	33	22	33 inch Pre-commission CHEMICAL pipeline operated by CONOCOPHILLIPS	2017 to 2018	No	Yes
		PLU3122 - Juliet to Pickerill A umbilical	89	50	138 mm Pre-commission MIXED HYDROCARBONS pipeline operated by ENGIE	2017 to 2018	No	Yes
		PL3088 - Cygnus to ETS gas pipelines	48	64	24 inch Pre-commission GAS pipeline operated by ENGIE	2017 to 2018	No	Yes
		PL3086 - Cygnus A to Cygnus B gas pipelines	65	78	12 inch Pre-commission GAS pipelines operated by ENGIE	2017 to 2018	No	Yes
		PL2894 - Katy to Kelvin gas export pipelines	39	53	10 inch Pre-commission GAS pipeline operated by CONOCOPHILLIPS	2019 to 2021	Yes	Yes
		PL2895 - Kelvin to Katy methanol pipelines	39	53	2 inch Pre-commission METHANOL pipeline operated by CONOCOPHILLIPS	2019 to 2021	Yes	Yes
		PL3121 - Juliet to Pickerill A gas pipelines	*89*	*50*	12 inch Pre-commission MIXED HYDROCARBONS pipeline operated by ENGIE	*2019 to 2021*	*Yes*	*Yes*
	Under-construction	PL0219 - PR K4-Z to K5-A	*20*	35	6 inch under construction gas pipeline operated by Total E&P Nederland B.V.	2017 to 2018	No	Yes
		PL0219 - UM K4-Z to K5-A	*20*	35	5 inch under construction control pipeline operated by Total E&P Nederland B.V.	2017 to 2018	No	Yes
	Proposed	PLU3087 – Cygnus A to Cygnus B umbilical	*65*	79	193.3 mm chemical pipeline operated by ENGIE	2019 to 2021	Yes	Unknown
		PL0221 - HS D18-A to D15-FA-1	*19*	45	2 inch proposed methanol pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
		PL0221 - PR D18-A to D15-FA-1	*19*	45	8 inch proposed gas pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
	Military operations							
	Operational	RWS Dutch military UXO clearance	Unknown	Unknown	Detonations of UXOs of unknown charge size or quantity	N/A	Unknown	Unknown
	Coastal Development (ports and harbours)							
	Approved	Yorkshire Harbour and Marina, Bridlington	157	148	Construction of a 250 berth marina, no piling	2019 to 2020	No	Yes
		Chatham Maritime Marina, Medway, N. Kent	296	177	Construction of 54 berth marina with up to 13 piles	2017 to 2018	No	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three array (km) (nearest point)	Distance from Hornsea Three offshore cable corridor (km) (nearest point)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
		Chatham Maritime Marina extension, Medway, N. Kent	296	177	Extension to existing pontoon providing an additional 60 berths	Unknown	Unknown	Yes
		Oikos Storage Ltd, Canvey Island, Essex	284	165	Construction of a new deep water jetty	2018	No	Yes
		Convoys Wharf, London	306	181	Construction of a new river bus jetty and associated structures	Unknown	Unknown	Yes
	Oil and Gas Decommissioning							
	Decommissioning	Leman BH	79 km	34 km	Gas platform	N/A	Yes (decommissioning activity overlapping with Hornsea Three construction	No
		Viking Charlie Drilling (CD)	39 km	22 km	Gas platform	N/A		No
		Viking Delta Drilling (DD)	37 km	21 km	Gas platform	N/A		No
		Viking Echo Drilling (ED	45 km	12 km	Gas platform	N/A		No
		Viking Golf Drilling (GD)	40 km	15 km	Gas platform	N/A		No
		Viking Hotel Drilling (HD)	33 km	13 km	Gas platform	N/A		No
		PL89 – Gas Pipeline (Decommissioning)	37.9 km	20.4 km	Pipelines associated with Viking field	N/A		No
		PL90 – Gas Pipeline (Decommissioning)	36.7 km	20.4 km		N/A		No
		PL91 – Gas Pipeline (Decommissioning)	37.9 km	11.5 km		N/A		No
		PL92 – Gas Pipeline (Decommissioning)	37.9 km	16.0 km		N/A		No
		PL93 – Gas Pipeline (Decommissioning)	33.3 km	17.7 km		N/A		No
		PL132 – Gas Pipeline (Decommissioning)	37.9 km	20.4 km		N/A		No
		PL131 – Gas Pipeline (Decommissioning)	36.7 km	20.4 km		N/A		No
		PL133 – Gas Pipeline (Decommissioning)	37.9 km	11.5 km		N/A		No
		PL66 – Gas Pipeline (Decommissioning)	37.9 km	16.0 km		N/A		No
		PL130 – Gas Pipeline (Decommissioning)	33.3 km	17.7 km		N/A		No
		Vulcan UR	67.4 km	12.9 km	Gas platform	N/A		No
		Viscount VO	50 km	15 km	Gas platform	N/A		No
		Vampire/Valkyrie	45 km	4 km	Gas platform	N/A		No
		PL462 - Vulcan UR to Vulcan RD	67.4 km	12.9 km	Pipeline associated with Vulcan platforms	N/A		No
		PL463 - Vulcan RD to Vulcan UR	67.4 km	12.9 km	Pipeline associated with Vulcan platforms	N/A		No
		PL1962 - Viscount VO to Vampire OD	44.7 km	4.5 km	Pipeline associated with Viscount and Vampire platforms	N/A		No

Tier	Phase	Project/Plan	Distance from Hornsea Three array (km) (nearest point)	Distance from Hornsea Three offshore cable corridor (km) (nearest point)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
		PL1963 - Vampire OD to Viscount VO	44.7 km	4.5 km	Pipeline associated with Viscount and Vampire platforms	N/A		No
		PL1692 - Vampire OD to LOGGS PR	44.7 km	4.4	Pipeline associated with Vampire platform	N/A		No
		PL1693 - LOGGS PR to Vampire OD	44.7 km	4.4	Pipeline associated with Vampire platform	N/A		No
		Audrey A (WD)	39 km	1	Gas platform	N/A		No
		Audrey B (XW)	39 km	6	Gas platform	N/A		No
		PL496	39.0 km	0 (Crosses route)	Pipelines associated with Audrey field	N/A		No
		PL497	39.0 km	0 (Crosses route)		N/A		No
		PL723	38.6 km	1.3 km		N/A		No
		PL724	38.6 km	1.3 km		N/A		No
		PL575	39.0 km	1.3 km		N/A		No
		PL576	39.0 km	1.3 km		N/A		No
2	**Offshore wind farms**							
	Consented	Dogger Bank Teesside A and B	95	108	Up to 400 turbines consented	2023 to 2026	Yes	Yes
		Dogger Bank Creyke Beck A and B	76	91	Up to 200 turbines consented	2021 to 2024	Yes	Yes
		East Anglia Three	103	87	Up to 172 turbines	2020 to 2022	Yes	Yes
	Aggregate extraction and disposal sites							
	Application	Humber 4 and 7 - 506	13 km	8 km	Application for operation sought up to 31 December 2029	N/A	Yes (operational activity overlapping with Hornsea Three construction)	No
		Humber 5 - 483	14 km	2 km	Application for operation sought up to 31 December 2029	N/A	Yes (operational activity overlapping with Hornsea Three construction)	No
		Inner Dowsing - 439	131 km	48 km	Application for operation sought up to 31 December 2029	N/A	Yes (operational activity overlapping with Hornsea Three construction)	No
	Cables and pipelines							
	Proposed	Viking Link Interconnector	13	18	High voltage (up to 500 kV) DC electricity interconnector	2019 to 2021	Yes	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three array (km) (nearest point)	Distance from Hornsea Three offshore cable corridor (km) (nearest point)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
		PL0221_HS D18-A to D15-FA-1	19 km	45 km	2-inch Proposed Methanol pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
		PL0221_PR D18-A to D15-FA-1	19 km	45 km	8-inch Proposed Gas pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
3	**Offshore wind farms**							
	Proposed	Norfolk Vanguard	73	51	Up to 1,800 MW and between 120 to 257 turbines	2022 to 2024	Yes	Yes
		Moray West	554	570	Up to 90 8 to 15 MW turbines	2022 to 2023	Yes	Yes

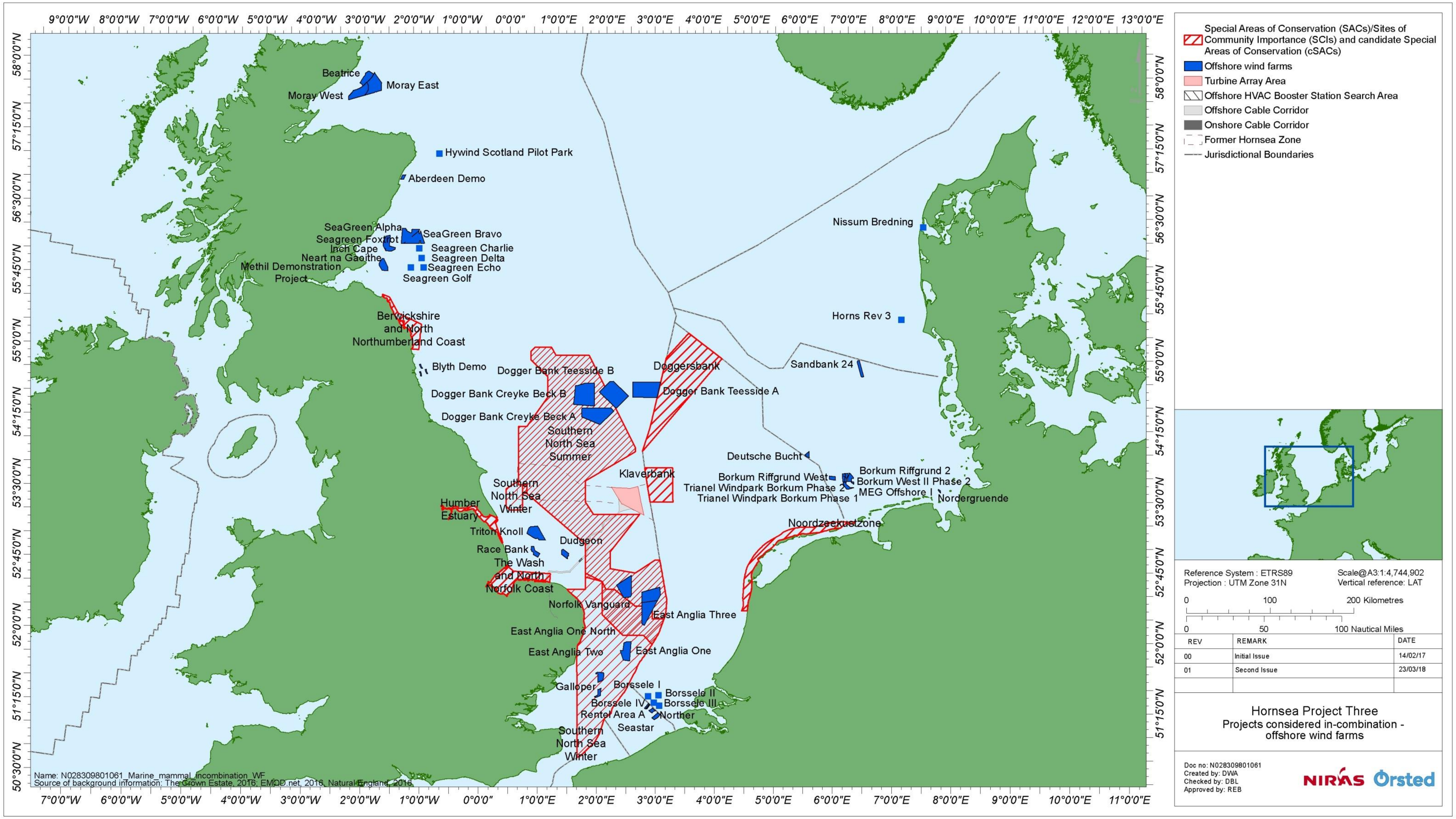


Figure 6.19: Offshore wind farms and coastal development projects screened into the marine mammal in-combination assessment.

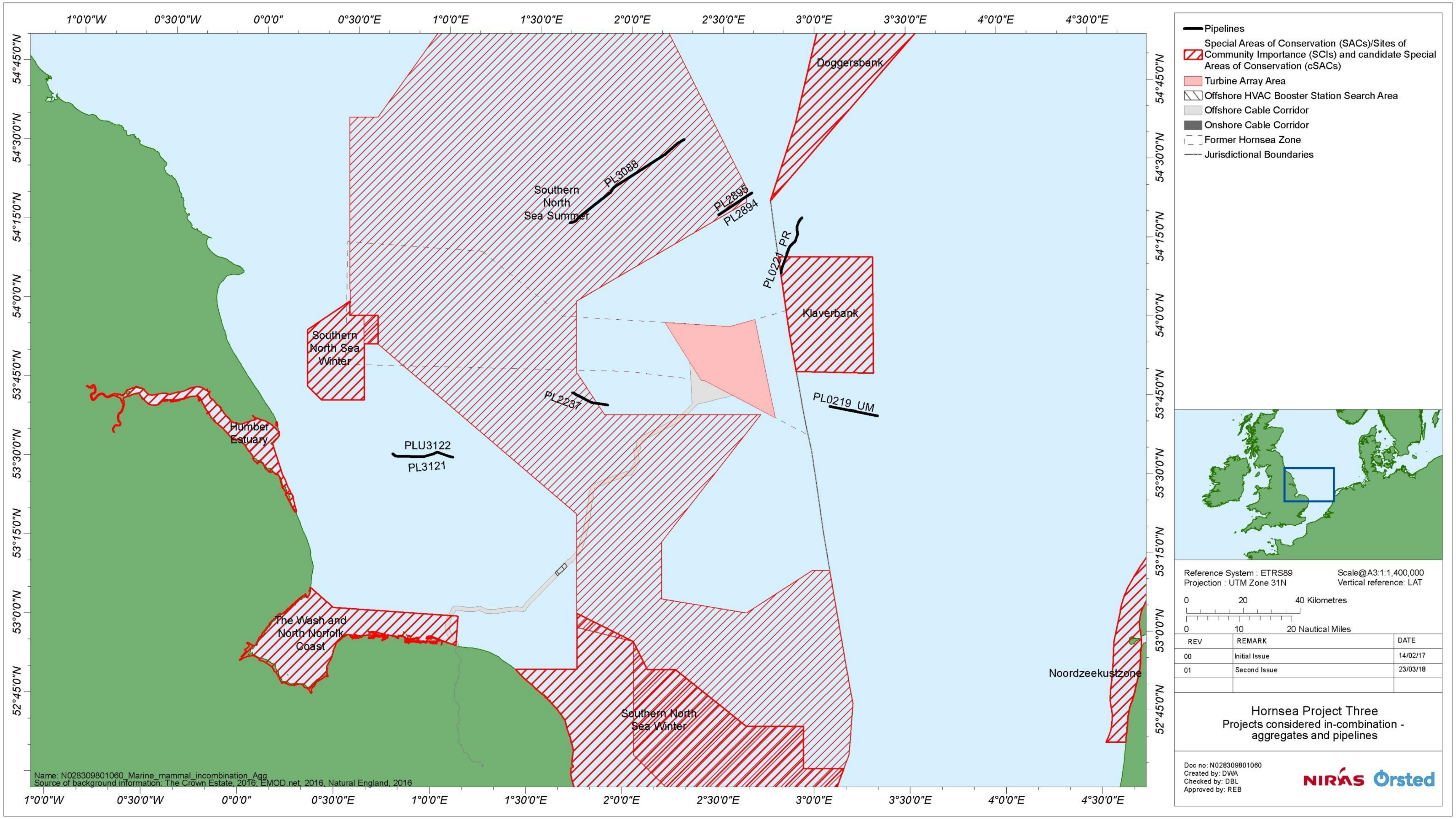


Figure 6.20: Pipelines and cables screened into the marine mammal in-combination assessment.

Table 6.24: Maximum design scenario considered for the assessment of potential in-combination impacts on marine mammals.

Potential impact	Maximum design scenario	Justification
Underwater noise from foundation piling and other construction activities (e.g. drilling of piles) within the Hornsea Three with underwater noise arising during construction of other projects has the potential to cause injury or disturbance to marine mammals.	The maximum design scenario as described and assessed for the construction phase impacts for Hornsea Three cumulatively with the following projects: *Tier 1* • Under construction offshore wind farms: Dudgeon; Hornsea Project One; Beatrice; and Galloper; • Consented offshore wind farm applications: Blyth demo; East Anglia One; East Anglia Three; Hornsea Project Two; Kincardine; Triton Knoll; Hywind Scotland Pilot Park, Moray East, Borssele 3 and 4, Inch Cape, Neart Na Gaoithe and Sea Green; • Dutch military activities – UXO clearance and mine clearance training; and • Pile-driving activities associated with ports and harbour developments including: Chatham Maritime Marina (pontoon extension); Oikos Storage Ltd, Convoys Wharf. *Tier 2* • Consented offshore wind farm applications: Dogger Bank Creyke Beck A and B; Dogger Bank Teesside A and Dogger Bank Teeside B (now Sofia);. *Tier 3* • Unconsented offshore wind farms: Norfolk Vanguard; Moray West.	Maximum design scenario includes projects whose construction phase overlaps with the construction phase for Hornsea Three, resulting in maximum design spatial scenario. Maximum design temporal scenario considers the longest duration of the piling phase for each of the projects not included as part of the baseline. Where projects do not overlap but run consecutively, it is assumed that piling could occur at any point within the construction phase therefore giving the longest duration of a potential piling phase. Maximum design scenario for Dutch military activities assumes that UXOs will be cleared via detonation of devices. Maximum design scenario for ports and harbours assumes an increase in subsea noise arising from projects that involve pile-driving activity during construction. Projects have been screened out where there is a very short piling duration (less than one month), or very few piles to be installed (less than ten), and/or the project is over 200 km distance from the nearest point in Hornsea Three. Noise impacts arising from aggregate extraction and cable and pipeline installation have been screened out on the basis that these are considered to be highly localised, short term, and of negligible magnitude. In addition, all oil and gas activities listed in the cumulative screening table are currently operational and therefore were considered to be part of the baseline and screened out for cumulative impacts of subsea noise.
Increased traffic during construction, operation or decommissioning of Hornsea Three may result in an increase in disturbance, collision risk or injury to marine mammals during construction, operation or decommissioning of other projects.	The maximum design scenario as described and assessed for the construction phase impacts for Hornsea Three cumulatively with the following projects (listed for the whole of the North Sea): *Tier 1* • Under construction offshore wind farms: Dudgeon; Beatrice; Race Bank; Hornsea Project One; and Galloper; • Consented/submitted offshore wind farm applications: Aberdeen demo; Blyth demo, Dogger Bank Creyke Beck A and B; Dogger Bank Teesside A and B; East Anglia One; East Anglia Three; Hornsea Project Two; Kincardine; Triton Knoll; Hywind Scotland Pilot Park, MORL Eastern Development Area; Inch Cape; Neart Na Gaoithe and Sea Green • All cables and pipelines listed in Table 6.23; apart from the Viking Interconnector • Ports and harbour projects including: Yorkshire Harbour and Marina, Chatham Maritime Marina (two projects). *Tier 2* • Norfolk Vanguard, Moray West; and • Viking Interconnector.	For offshore energy developments, projects are included where the construction or operation phase overlaps with the construction or operation phase of Hornsea Three, provided that the project is not already operational and therefore part of the baseline. Projects screened in are expected to contribute to an increase in vessel traffic during construction and during operation and maintenance activities. Increased vessel activity from dredging activities and Dutch military activities have been screened out on the basis that the uplift in vessel numbers is predicted to be very small and vessel movements localised, therefore the magnitude of impact will be negligible. Cables and pipelines are included if the operational phase has not already commenced (i.e. not part of the baseline). For ports and harbours, vessel traffic during construction phase is screened out on the basis that the uplift in vessel numbers is predicted to be very small and/or vessel movements highly localised; therefore the magnitude of impact will be negligible. During operation, the impact of vessel traffic is screened in where there is an extension to an existing facility or an installation of a new facility resulting in additional berths for more than 25 vessels, therefore leading to a potential increase in vessel traffic.

6.7 Assessment of potential adverse effect on site integrity in-combination with other plans and projects

6.7.1.1 A description of the potential in-combination effects on Annex II marine mammal features arising from each identified impact is given below. The scale over which the effects have been assessed for each marine mammal species is based upon the criteria of the screening exercise described above and within the relevant MU for each species, as discussed and agreed with the Marine Mammal EWG.

6.7.2 Underwater noise

6.7.2.1 During the offshore construction of Hornsea Three, the main source of in combination increase in underwater noise is likely to occur as a result of piling operations from other projects, plans and activities. The projects included in this in combination assessment are detailed in Table 6.23 and include offshore wind farms and coastal developments within the wider North Sea MU (as agreed with the Marine Mammal EWG) where piling is considered likely to occur during construction phases of these projects, and where there is potential for direct overlap of piling phases, or where piling commences within five years of commencement or completion of piling at Hornsea Three (Table 6.25).

6.7.2.2 The maximum design scenario (temporal) for potential cumulative impact of increased underwater noise due to piling is 12 years (the total duration of piling for all projects screened into the CEA (i.e. including projects that are before Hornsea Three but screened in as not yet built/part of the baseline), with a gap of three years where currently no piling is predicted to occur. Up to 36 offshore wind farm projects are planned to be constructed within the cumulative period, and therefore may have the potential for an in-combination impact on marine mammal populations potentially affected by piling at Hornsea Three. However, within Tier 1, only three projects are currently predicted as likely to have a directly overlapping piling period with Hornsea Three (Triton, Knoll, Hornsea Two and Moray East). In Tier 2, five projects have the potential for direct overlap of piling phases (Dogger Bank Creyke A & B, Dogger Bank Teesside A & Dogger Bank Teeside B (now Sofia) & East Anglia Three,). In Tier 3 three projects have potential for direct overlap of piling phases (Moray West, Norfolk Vanguard and Thanet Extension).

6.7.2.3 The potential for in combination impacts of pile-driving has been assessed for Hornsea Three based on the maximum adverse spatial scenario of piling at two concurrent locations within the Hornsea Three array area using 5,000 kJ hammer energies, with a maximum spacing between piling activities; and where a quantitative assessment was possible and appropriate (behavioural impacts on harbour porpoise and seals) the maximum design scenario has been presented for associated in-combination projects (Table 4.2). This is likely to be a highly precautionary approach to assessment as the maximum design scenario for each project is highly unlikely to occur the majority of the time, and at every project concurrently.

6.7.2.4 It should be noted that the in-combination noise assessment has been based on information and assessments, where available, as presented in the published Environmental Statements. Though Table 6.25 suggests that there may be an overlap in the timing of piling of up to ten offshore projects with the Hornsea Three piling phase, construction timescales are indicative and subject to change, however the tiering approach is intended to take into account this uncertainty in timing and therefore more weight should be placed on tier one than on subsequent tiers.

6.7.2.5 Piling at Hornsea Three is likely to occur in two short phases (approximately a year and a half) within the eight year offshore construction period, with a maximum duration of three years between phases where no piling will occur (Table 6.25). In addition, assessment of the potential effects on marine mammals predicted by other wind farms is not directly comparable to those presented for Hornsea Three due to different approaches to assessment taken by other offshore developers, different noise criteria and thresholds used, and differing levels of detail presented in associated Environmental Statements.

6.7.2.6 The majority of planned developments do not have overlapping construction periods with Hornsea Three. The main potential in combination impacts are predicted to occur during periods of overlapping piling where increased anthropogenic noise is highest, and these are the projects that are assessed quantitatively where possible and appropriate. A qualitative assessment has been undertaken of potential in combination impacts of projects where there is no overlap of piling period with Hornsea Three predicted.

Table 6.25: Projected timelines of piling of in-combination projects, and potential for overlap with Hornsea Three piling (2022 to 2032). Red outline denotes the periods of overlap with the two piling periods for Hornsea Three.

Tier	Project	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033 to 2038
	Hornsea Three																	
1	Blyth Demo																	
	Beatrice																	
	Borkum Riffgrund 2 (Germany)																	
	Borssele 1 and 2 (Netherlands)																	
	Borssele 3 and 4 (Netherlands)																	
	Deutsche Bucht Offshore Wind Farm (Germany)																	
	Dudgeon	commissioned by 2017																
	East Anglia One																	
	Galloper																	
	Hornsea Project One																	
	Hornsea Project Two																	
	Horns Rev 3 (Denmark)																	
	Hywind Scotland Pilot Park																	
	Kincardine																	
	MEG Offshore (now Merkur offshore windfarm)																	
	Moray East																	
	Nissum Bredning (Denmark)																	
	Nordergruende																	
	Norther (Belgium)																	
	Rentel Area A (Belgium)																	
	Sandbank 24																	
	Seastar (Belgium)																	
	Trianel Windpark Borkum (Germany																	
	Triton Knoll																	
	Chatham Maritime Marina and extension																	

Tier	Project	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033 to 2038
	Convoys Wharf	Unknown																
2	Dogger Bank Creyke A & B																	
	Dogger Bank Teeside A																	
	Dogger Bank Teeside B (now Sofia)																	
	East Anglia Three																	
3	Moray West																	
	Norfolk Vanguard																	
	Thanet Extension																	

Harbour porpoise and pinniped auditory injury

<u>Tier 1</u>

6.7.2.7 The potential impacts of subsea noise from pile-driving on marine mammal Annex II features has been detailed within the alone assessment and have not been re-iterated here.

Auditory injury (PTS)

6.7.2.8 The potential distances at which auditory injury (PTS) could occur in marine mammals during concurrent pile-driving at Hornsea Three are very small (Table 6.11). At 15% hammer blow energy, for all scenarios, the potential for auditory injury falls within the standard 500 m mitigation range recommended in the JNCC guidelines (JNCC, 2010b). The potential distances at which PTS could occur as a result of cumulative exposure were up to a maximum of 1,200 m for harbour porpoises and 100 m for seals. Assuming that mitigation is implemented as set out in the MMMP, which may include use of marine mammal observers and ADDs, the risk of auditory injury (PTS) will be reduced to negligible and therefore significant effects (in EIA terms) are unlikely to occur. In addition, other projects' impact assessments for subsea noise from pile-driving have presented smaller hammer energies and are highly likely to follow good practice in implementation of mitigation measures such as use of marine mammal observers and ADDs, therefore the potential ranges for auditory injury (PTS) from other projects are likely to be no greater than that for HOW03.

6.7.2.9 All projects will have mitigation in place that aims to ensure that the magnitude of any impact will be very low and adverse effects will not occur. Given the population size and as potential impact ranges are small potential impacts are considered unlikely for Hornsea Three alone for the maximum design spatial scenario. Therefore, there is no risk of in-combination effects having a combined increase risk than that for project alone assessment and no further assessment for potential in-combination impact of auditory injury has been carried out.

6.7.2.10 As the potential for behavioural effects on seals due to concurrent piling at Hornsea Three is only predicted to affect very small numbers of animals, these receptors are not considered further for the in-combination impact of behavioural effects from piling noise.

Conclusions

The Wash and North Norfolk Coast SAC

6.7.2.11 Based on the information presented above, at this stage, there is no indication that in-combination lethality/ injury and hearing impairment or behavioural effects associated with underwater noise on the harbour seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.7.2.12 Based on the information presented above, there is no indication that in-combination lethality/ injury and hearing impairment or behavioural effects associated with underwater noise on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.7.2.13 Based on the information presented above, there is no indication that in-combination lethality/ injury and hearing impairment or behavioural effects associated with underwater noise on the grey seal qualifying feature of this site would result in a permanent shift in the population or the distribution of the feature within this SAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC (auditory injury only – behavioural effects assessed separately)

6.7.2.14 Based on the information presented above, there is no indication that the potential for in-combination auditory injury and hearing impairment effects associated with underwater noise on the harbour porpoise qualifying feature of this site would lead to a reduction in the viability of the species or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained.

6.7.2.15 Furthermore, due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the population or the distribution of the features within this cSAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI (auditory injury only for harbour porpoise)

6.7.2.16 Based on the information presented above, there is no indication that the potential for auditory injury and hearing impairment or behavioural effects associated with underwater noise on the harbour and grey seal features or for auditory injury and hearing impairment (PTS and TTS) effects on the harbour porpoise feature of this site would lead to a reduction in the extent or quality of the habitat in order to maintain the populations and due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the population or the distribution of the features within this SCI in the long term . Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.7.2.17 Based on the information presented above, there is no indication that the potential for in-combination lethality/ injury and hearing impairment or behavioural effects associated with underwater noise on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.7.2.18 Based on the information presented above and with respect to the Conservation Objectives for the SAC potentially impacted, the potential for in-combination lethality/ injury and hearing impairment or behavioural effects associated with underwater noise on the grey seal feature of this site would not prevent the extent and quality of habitat in order to maintain the population from being maintained. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

Harbour porpoise – behavioural effects

6.7.2.19 Within Tier 1, only three projects are currently predicted to have a directly overlapping piling period with Hornsea Three (Triton Knoll, Hornsea Project Two and Moray East), in Tier 2, five projects have potential for direct overlap of piling phases (Dogger Bank Creyke A & B, Dogger Bank Teesside A & Dogger Bank Teeside B (now Sofia) & East Anglia Three). In Tier 3 three projects have potential for direct overlap of piling phases (Moray West, Norfolk Vanguard and Thanet Extension) (Table 6.26 to Table 6.29). Moray East and Moray West lie more than 26 km from the Southern North Sea cSAC and, therefore, have not been considered further.

6.7.2.20 As for the assessment of harbour porpoise disturbance effects alone, it is assumed that the disturbance range is 26 km from the location of each percussive piling event, regardless of the type of foundation installed. This range has been applied to all projects. Final foundation layouts are not available for all offshore wind farm projects included within the assessment. A maximum and minimum range can only be established based on possible locations within the consented order limits. This means that whilst the range of effect at any one time can be readily quantified, the average effect over the season adopts a more semi-quantified approach.

6.7.2.21 The spatial extent of disturbance is presented for sequential and concurrent piling schedules, providing the range of in-combination effects (median, maximum and minimum) for Hornsea Three and other relevant plans, projects and proposals. The table does not take account of any temporal element, or any spatial overlap of disturbance between projects (i.e. double counting) and therefore should not be taken in isolation.

6.7.2.22 None of the projects identified are within 26 km of the Klaverbank SCI, and therefore there will be no in-combination behavioural effect on harbour porpoise at that site. The assessment of in-combination effects, therefore, focuses only on the Southern North Sea cSAC.

6.7.2.23 There is the potential requirement for explosions for UXO clearance prior to construction of other wind farms in the North Sea, as well as UXO clearance by the Royal Netherlands Navy (as described in von Benda-Beckman *et al.,* (2015)). It is not possible to carry out a reliable quantitative assessment of the extent of UXO clearance related detonations overlapping with noisy construction activities at Hornsea Three. UXO detonations occur over a very short duration and any disturbance effect is assumed to be temporary. Therefore, there is unlikely to be an in-combination effect of underwater noise from the construction of Hornsea Three with UXO detonations elsewhere in the North Sea.

6.7.2.24 The potential for significant impact from a combination of pile driving at Hornsea Three and oil and gas activities is largely related to the anticipated type, extent and duration of seismic survey. Seismic surveys involve a wide range of equipment, with various sound source levels. The information available for this assessment did not allow the separation of the equipment used or provide information on the noise source levels generated and therefore it is not possible to undertake a quantitative assessment. Oil and gas activities are licenced in the UK by the Department for Business, Energy & Industrial Strategy (BEIS) and there is no easily accessible central repository for detailed information on planned or likely future activities over the timescales required for this assessment. In 2016 JNCC launched the Marine Noise Registry (MNR; JNCC (2016)) which is a database that records the spatial and temporal distribution of impulsive noise generating activities in UK seas. In the absence of detailed information on likely future activity, this assessment has taken the outputs from the noise registry from 2015 as indicative of future levels of activity in the wider management unit, although it is unlikely that areas previously subject to detailed seismic survey will be subject to re-survey.

6.7.2.25 Overall levels of seismic survey activity in 2015 as recorded in the MNR were low, generally between 1 and 10 days of activity across the year, with only a small number of blocks experiencing higher levels (>10 to 99 pulse block days). The Hornsea Three array area overlaps with a total of 6 licence blocks and the cable corridor overlaps with 7 licence blocks. Oil and Gas activities within the Southern North Sea CSAC have also been considered. According to TNO (Heinis *et al.,* 2015) seismic surveying activity in the years 2016-2022 are not expected to differ from levels prior to 2016 and although year to year variations are expected, in general, ongoing activities can be considered as part of the baseline conditions.

6.7.2.26 Following advice from Natural England (Natural England, 2017b), this assessment assumes an area of 10 km radius (314 km^2) around each seismic operation to assess the area of potential disturbance. It is not possible to reliably estimate the number of potential seismic surveys that could be undertaken within the Southern North Sea cSAC area during the construction and potential piling activity at Hornsea Three. Therefore, the assessment has been based on a nominal prediction of a total of four seismic surveys ongoing at the same time as the piling activity for the construction of Hornsea Three. There is potential for overlap of 3.4% of the entire cSAC.

6.7.2.27 There is much uncertainty regarding the potential for in-combination effects of noise disturbance from a combination of pile driving and seismic survey. There is little empirical data on the effect of seismic surveys on marine mammals. One study in the Moray Firth, Scotland, demonstrated that disturbance effects in harbour porpoises occurred over ranges of 5-10 km but that effects were short-lived and animals were typically detected again at affected sites within a few hours (Thompson *et al.,* 2013b). This study demonstrated that there was no long-term displacement into sub-optimal or higher risk habitats. A follow up analysis using the same data (Pirotta *et al.* 2014) demonstrated that feeding activity was reduced in the ensonified area (measured by the probability of measuring a porpoise echolocation 'buzz', a behaviour thought to be indicative of foraging attempts) by 15%.

Table 6.26: In-combination spatial effect range (sequential piling) for the Southern North Sea cSAC summer component

Project	Overlap of summer cSAC (km^2)		% of summer cSAC	
Hornsea Three	Median: 1254.0	Max: 2145.9 Min: 362.1	Median: 4.65	Max: 8.00 Min: 1.30
Tier 1				
Hornsea Two	Median: 1035.0	Max: 1983.2 Min: 86.8	Median: 3.83	Max:7.35 Min: 0.32
Triton Knoll	Median: 48.9	Max: 97.8 Min: 0.0	Median: 0.16	Max: 0.36 Min: 0.0
Total for Tier 1	***Median: 1083.9***	***Max: 2081.0 Min: 86.8***	***Median: 4.09***	***Max: 7.7 Min: 0.32***
Tier 2				
Dogger bank Creyke A & B	Median: 3528.9	Max: 4245.3 Min: 2610.2	Median: 13.07	Max: 15.71 Min: 9.66
Dogger bank Teesside A & B	Median: 834.0	Max: 1525.4 Min: 129.3	Median: 3.09	Max: 5.56 Min: 0.48
East Anglia Three	Median: 1833.2	Max: 2123.7 Min: 1546.4	Median: 6.79	Max: 7.86 Min: 5.72
Total for Tier 2	***Median: 6090.2***	***Max: 7894.4 Min: 4285.9***	***Median: 22.95***	***Max: 29.13 Min: 15.87***
Tier 3				
Norfolk Vanguard	Median: 1734.5	Max: 2123.7 Min: 1345.4	Median: 6.42	Max: 7.86 Min: 4.98

Table 6.27: In-combination spatial effect range (concurrent pilling) for the Southern North Sea cSAC summer component

Project	Overlap of summer cSAC (km^2)		% of summer cSAC	
Hornsea Three	Median: 1287.4	Max: 2223.6 Min: 351.2	Median: 4.77	Max: 8.23 Min: 1.30
Tier 1				
Hornsea Two	Median: 1493.5	Max: 2876.8 Min:110.1	Median: 5.55	Max: 10.7 Min: 0.41
Triton Knoll	Median: 56.0	Max: 102.0 Min:0.0	Median: 0.19	Max: 0.38 Min:0.0

Project	Overlap of summer cSAC (km²)		% of summer cSAC	
Total for Tier 1	***Median: 1549.5***	***Max: 2978.8 Min: 110.1***	***Median: 5.74***	***Max: 11.1 Min: 0.41***
Tier 2				
Dogger bank Creyke A & B	Median: 4015.5	Max: 5367 Min: 2663.9	Median: 14.86	Max: 19.86 Min: 9.86
Dogger bank Teesside A & B	Median: 1110.9	Max: 2073.9 Min: 147.9	Median: 4.11	Max: 7.68 Min: 0.55
East Anglia Three	Median: 2301.4	Max: 3025.7 Min: 1577	Median: 8.52	Max: 11.20 Min: 5.84
Total for Tier 2	***Median: 7427.7***	***Max: 10,466.6 Min: 4,388.8***	***Median: 27.49***	***Max: 38.74 Min: 16.25***
Tier 3				
Norfolk Vanguard	Median: 2618.5	Max: 3891.73 Min: 1345.35	Median: 9.70	Max: 14.41 Min: 4.98

Table 6.28: In-combination spatial effect range (sequential piling) for the Southern North Sea cSAC winter component

Project	Overlap of winter cSAC (km²)		% of winter cSAC	
Hornsea Three	Median: 46.3	Max: 92.6 Min: 0	0.37	Max: 0.73 Min: 0
Tier 1				
<u>Triton Knoll</u>	Median: 10.0	Max: 20.0 Min:0.0	Median: 0.08	Max: 0.16 Min: 0.0
Tier 2				
East Anglia Three	Median: 1057.9	Max: 1827.35 Min: 288.4	Median: 8.34	Max: 14.4 Min: 2.27
Tier 3				
Norfolk Vanguard	Median: 540.8	Max: 1081.35 Min: 0.28	Median: 4.26	Max: 8.52 Min: 0.002
Thanet Extension	Median: 939.57	Max: 1304.0 Min: 575.2	Median: 7.4	Max: 10.3 Min: 4.5
Total for Tier 3	*Median: 1480.37*	*Max: 2385.3 Min: 575.5*	*Median: 11.65*	*Max: 18.8 Min: 4.5*

Table 6.29: In-combination spatial effect range (concurrent piling) for the Southern North Sea cSAC winter component

Project	Overlap of winter cSAC (km²)		% of winter cSAC	
Hornsea Three	Median: 46.3	Max: 92.6 Min: 0	Median: 0.37	Max: 0.73 Min: 0
Tier 1				
<u>Triton Knoll</u>	Median: 10.0	Max: 20.0 Min:0.0	Median: 0.08	Max: 0.16 Min: 0.0
Tier 2				
East Anglia Three	Median: 1135.2	Max: 1981.96 Min: 288.4	Median: 8.95	Max: 15.62 Min: 2.27
Tier 3				
Norfolk Vanguard	Median: 731.1	Max: 1461.8 Min: 0.28	Median: 5.76	Max: 11.52 Min: 0.002
Thanet Extension	Median: 1030	Max: 1445.5 Min: 614.5	Median: 8.1	Max: 11.4 Min: 4.8
Total for Tier 3	*Median: 1761.1*	*Max: 2907.4 Min: 614.8*	*Median: 13.85*	*Max: 22.9 Min: 4.8*

<u>Tier 1</u>

6.7.2.28 Table 6.26 and Table 6.27 show that for Hornsea Project Three in-combination with Tier 1 projects the median spatial 'one off' overlap with the summer component of the cSAC is 8.7% based on the worst case of sequential piling and 10.5% based on the worst case of concurrent piling neither of which exceed the 20% threshold. When potential for overlap with seismic surveys is included in this, this increases to 12.1% and 13.9% respectively, which stil remain well below the 20% threshold.

6.7.2.29 Table 6.28 and Table 6.27 show that for Hornsea Project Three in-combination with Tier 1 projects the median spatial 'one off' overlap with the winter component of the cSAC is 0.45% for both the worst case of sequential piling and concurrent piling neither of which exceed the 20% threshold.

6.7.2.30 The in-combination assessment uses each projects' maximum design scenario, and therefore is inherently conservative. There is likely to be a great variation in timing, duration and hammer energy used throughout the various project construction periods. A combined maximum extent of disturbance would only occur if all the activities listed under Tier 1, in addition to any possible seismic surveys from oil and gas activities, took place at the same time and in their respective worst case locations, which is unlikely and representative of a one off maximum event. The combined maximum extent given also assumes no overlap in terms of the area subject to disturbance per activity and is therefore likely to incorporate double counting.

6.7.2.31 The average effect for each project over the season provides a more realistic interpretation of how any temporal effect may occur. In addition, when considering the duration of effect with regard to the average seasonal footprint, it is unlikely for there to be piling activity on every day of the season or that piling will occur across the entire construction period. Furthermore, the proportion of the population affected over the construction period will vary considerably between the Tier 1 project locations, as the maximum design scenario assumes that all the animals disturbed could potentially be displaced during piling activity at each location. A number of precautionary assumptions have been made while undertaking this assessment around projects building out to their maximum consent design, the worst case scenario for the projected timescale and enough installation vessels being available to enable all projects to be constructed simultaneously. These assumptions result in a highly precautionary assessment on the disturbance to harbour porpoise, with industry experience showing that only a couple of projects will actually be developed per year.

<u>Tier 2</u>

6.7.2.32 The addition of the Tier 2 projects will increase the percentage overlap of the Southern North Sea cSAC. In Tier 2, with a median overlap of 22.95% . The inclusion of East Anglia Three would increase the median percentage overlap of the cSAC winter component by 8.3%. There is no certainty as to whether Tier 2 projects will obtain a Cfd and considerable further uncertainty as to their final form and the timescale over which they may actually come forward.

6.7.2.33 The in-combination assessment uses each projects' maximum design scenario, and therefore is inherently conservative. There is likely to be a great variation in timing, duration and hammer energy used throughout the various project construction periods. A combined maximum extent of disturbance would only occur if all the activities listed under Tier 2 took place at the same time and in their respective worst case locations, which is unlikely and representative of a one off maximum event. The combine maximum extent given also assumes no overlap in terms of the area subject to disturbance per activity and is therefore likely to incorporate double counting.

6.7.2.34 The average effect for each project over the season will be less than the maximum one off spatial overlap. When considering the duration of effect with regard to the average seasonal footprint, it is unlikely for there to be piling activity on every day of the season or that piling will occur across the entire construction period. Furthermore, the proportion of the population affected over the construction period will vary considerably between the Tier 2 project locations, as the maximum design scenario assumes that all the animals disturbed could potentially be displaced during piling activity at each location.

6.7.2.35 A number of precautionary assumptions have been made while undertaking this assessment around projects building out to their maximum consented design, the worst case scenario for the projected timescale, all projects obtaining CfD's and enough installation vessels being available to enable all projects to be constructed simultaneously. These assumptions therefore result in a highly precautionary assessment on the disturbance to harbour porpoise with industry experience showing that only a couple of projects will actually be developed per year.

<u>Tier 3</u>

6.7.2.36 The addition of the Tier 3 projects will increase the percentage overlap of the Southern North Sea cSAC. In Tier 3, only Norfolk Vanguard has the potential to overlap with the southern North Sea cSAC summer component, with a median overlap of 9.7% There is no certainty as to whether Tier 3 projects will achieve consent and considerable further uncertainty as to their final form and the timescale over which they may actually come forward.

6.7.2.37 A number of precautionary assumptions have been made while undertaking this assessment around projects building out to their maximum consented design, the worst case scenario for the projected timescale, all projects obtaining CfD's and enough installation vessels being available to enable all projects to be constructed simultaneously. These assumptions therefore result in a highly precautionary assessment on the disturbance to harbour porpoise with industry experience showing that only a couple of projects will actually be developed per year.

Conclusions

6.7.2.38 Based on the information presented above, with regard to the spatial extent of any potential impact and the very low likelihood of exceeding the 20% threshold, there is no indication that the potential for in-combination behavioural effects associated with underwater noise on the harbour porpoise qualifying feature of this site would lead to significant disturbance of the species or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained.

Furthermore, due to the temporary nature of the activity there is no indication that effects would result in a permanent shift in the population or the distribution of the features within this cSAC in the long term and subsequently no adverse effect on the population or distribution of this qualifying feature is anticipated. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC

Increased vessel traffic

6.7.2.39 Increased levels of marine vessel traffic during construction, operation or decommissioning of Hornsea Three may result in an increase in disturbance, collision risk or injury to marine mammals which are features of the sites identified in (Table 6.1) during construction, operation or decommissioning of other projects.

6.7.2.40 Marine mammals are particularly sensitive to increases in anthropogenic noise in the marine environment due to their reliance on sound for prey identification and capture, communication, and navigation. Potential impacts on marine mammals from increased noise due to increased vessel traffic could occur during construction, operational and maintenance, and decommissioning phases of Hornsea Three in-combination with other projects, plans and activities.

6.7.2.41 There is also potential for an in-combination increase in collision risk between vessels and marine mammals during construction, operation and maintenance, and decommissioning of Hornsea Three with other projects, plans and activities. Marine mammals may be more vulnerable to collision risk if they are not able to detect the approach of a vessel. For example, sound produced during piling operations may mask the presence of vessels, leading to reduced detection and avoidance by marine mammals which could lead to increased potential for vessel strikes to occur.

6.7.2.42 It is considered that there is a high likelihood of avoidance from both increased vessel noise and collision risk, with both a high potential for recovery (< 1 year) for increased noise, and medium potential for recovery for collision risk (Environmental Statement volume 4, annex 3.1: Subsea Noise Technical Report).

6.7.2.43 This in-combination assessment considers the effects of increased vessel noise on, and increased potential for collision with marine mammals site features, due to the potential increase in vessel movements from the construction, operation and maintenance, and decommissioning of the Hornsea Three offshore wind farm with other planned or existing projects, plans and activities. These are:

- Offshore wind farms where construction and/or operational and maintenance phases overlap with the construction and operational and maintenance phases of Hornsea Three;
- Operational phases of port and harbour developments where there is a potential for an uplift in vessel movements as a result of the development; and
- Cable and pipeline projects that have not yet commenced construction.

6.7.2.44 For harbour porpoise, projects, plans and activities have been considered within the North Sea MU area (Figure 6.3); for grey seals, developments have been considered where they lie within the South-East England and North-East England MU and for harbour seal, where developments are within the South-East England MU (Figure 6.5).

6.7.2.45 Details of marine mammal sensitivity and response to increased vessel traffic have been detailed in the alone assessment and have not been reiterated here.

Tier 1

6.7.2.46 Upon examination of data available for offshore wind, pipeline and cable, and coastal developments, it is clear that the greatest potential for cumulative/in-combination increase in vessel movements arises from the development of other offshore wind farm developments.

6.7.2.47 Thirteen offshore pipeline and cable projects and two coastal projects have been scoped into this in-combination assessment (Table 6.30). Vessel movements associated with cable and pipelines listed are likely to lead to only a very slight increase in vessel movements, particularly when considered against increased movements associated with offshore wind farm developments. Similarly, increased vessel movements associated with operational phases of port and harbour developments are likely to lead to only small or localised increases in vessel traffic and therefore can be considered negligible in relation to a potential in-combination increased collision risk or disturbance to marine mammals due to increased vessel movement in the relevant MU.

6.7.2.48 For coastal projects scoped into the in-combination assessment increased berthing facilities have been provided for 114 vessels at the Chatham maritime marina pontoon (total for two berthing extension projects at this location) and for 250 vessels at the Yorkshire Harbour and Marina which could lead to an increase in vessel use in the North Sea. It is unlikely however that all berthing facilities will be fully occupied at any one time, and it is likely that vessel movements will be localised, short duration and intermittent.

6.7.2.49 Table 6.30 summarises the indicative vessel movements predicted to be associated with offshore wind farm developments in the North Sea over the lifetime of Hornsea Three, including the construction, operation and maintenance, and decommissioning phases. The estimated uplift in vessel movements (return trips) associated with Hornsea Three is 10,474 over the construction period (two phases over eight years with up to three years between phases).

6.7.2.50 It has been assumed that at worst a similar uplift would occur in vessel numbers over for the decommissioning period. A total uplift of 2,822 per year was predicted over the operational lifetime of the project. As stated previously these numbers are based upon an assumption that the same (maximum) number of vessels transits would occur to/from port for each foundation installed. It is more likely that these trips will occur less frequently than assumed for the maximum design scenario. In addition, for a large proportion of time vessels will be moving slowly or stationary within the Hornsea Three array area. Therefore, for Hornsea Three alone vessel movements are likely to be an overestimate.

6.7.2.51 Similarly, for each of the projects included in the in-combination assessment the number of vessel movements represents a maximum design scenario. Where a range of vessel movements has been provided in project documents, the maximum number of vessel movements has been presented. The numbers presented do not reflect the fact that most construction vessels associated with offshore developments will be stationary or slow moving, are likely to follow pre-determined routes to and from ports, and will adhere to best-practice guidance regarding changes of speed and not approaching marine mammals.

6.7.2.52 Overall, baseline vessel use within the regional marine mammal study area which coincides with the North Sea MU is considered to be relatively high due to the presence of known shipping routes, ferry routes, and recreational boating areas. Marine mammals are therefore likely to show some degree of habituation to vessel movements (Sini *et al.*, 2005). Given the limited spatial extent of vessel movements from the projects considered in this in-combination assessment, with most activity confined to within the project area and transiting via existing routes, it is considered likely that marine mammals will tolerate the additional noise disturbance due to the increased vessel movements.

Table 6.30: Tier 1 In-combination assessment projects - vessel movements.

Project	Construction – number of vessel movements (return trips)	Operation and maintenance – number of vessel movements (return trips)
Under construction/approved offshore wind farms		
Dudgeon	Info not available	Info not available
Beatrice	Approximately 1,350 over construction period (approx. 675 per year)	Approximately 365 per year
Race Bank	~ 2,730 per year	704 per year
Hornsea Project One	6,966 over construction period (three phases over five years)	2,630 per year
Blyth demonstrator	Not available	Not available
Galloper	Not specified in Environmental Statement	Not specified in Environmental Statement
Consented/submitted offshore wind farms		
Aberdeen Bay Demonstrator	494 in total over 2 years	1,080 per year
Dogger Bank Creyke A & B	3,460 in total over 3 years	683 per year
Dogger Bank Teeside A & B	5,810 in total over 6 years	730 per year
East Anglia One	5,700 in total over 2.5 years	2,160 per year
East Anglia Three	8,000 (two phase approach) over 3.75 years	4,067 per year
Hornsea Project Two	6,200 in total over up to 7.5 years	2,817 per year
Kincardine	Minimal	78 per year (Minimal)
Triton Knoll	3,850 over 3 years	9,220 per year
Hywind Scotland Pilot Park	Minimal	Minimal
MORL Eastern Development Area	1,355 per construction period (4,065 total)	Not available/assessed as not significant
Inch Cape	3,500 over 1.5 years	Not available
Neart na Gaoithe	9,792 over 17 month construction period	1,550 per year
Sea Green (7 sub-projects)	4 vessels on site at any one time for each sub-project = 28 vessels in total at any one time over construction period	1,760 per year

Tier 2

6.7.2.53 The following developments have been assessed as Tier 2 projects in relation to potential for increased underwater noise from vessel traffic:

- Norfolk Vanguard offshore wind farm; and
- MORL western development area.

6.7.2.54 For Norfolk Vanguard, no details are available on the number of vessel movements associated with this development as the project is at the pre-application stage. There are expected to be crew transfers from port to the development area on a daily basis during construction and operation. As the project is expected to result in the installation of between 120 and 257 turbines, this has been estimated to result in a similar increase in vessel numbers during construction, and operation and maintenance phases as other offshore wind farms of a similar size (approximately 5,000 to 6,000 during construction and approximately 700 per year during operation and maintenance phases).

6.7.2.55 The MORL western development area is currently at scoping stage and no details for predicted vessel movements are available. However the MORL western development area Scoping Report does not predict a significant impact from increased vessel movements (Moray Offshore Renewables Ltd, 2016).

6.7.2.56 As discussed above, for each of the Tier 1 projects included in the in-combination assessment, the number of vessel movements represents a maximum design scenario and is likely to be overestimated. Given the lack of quantitative data available, and that Tier 2 only contributes an additional two projects over and above the 16 already included in the Tier 1 assessment, the assumption has been made that impacts of Tier 2 projects will not be greater than that already assessed for the Tier 1 projects.

6.7.2.57 The impact is therefore predicted to be of regional spatial extent, long term duration (lifetime of the project – 35 years), intermittent, and both reversible (disturbance due to increased vessel noise) and irreversible (collision risk). It is predicted that the impact will affect the feature both directly (collision risk) and indirectly (disturbance due to increased vessel movement).

Conclusions

The Wash and North Norfolk Coast SAC

6.7.2.58 Based on the information presented above, there is no indication that in-combination effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the harbour seal feature within this SAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis, there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Humber Estuary SAC/Ramsar

6.7.2.59 Based on the information presented above, there is no indication that in-combination effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the grey seal feature within this SAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

Berwickshire and North Northumberland Coast SAC

6.7.2.60 Based on the information presented above, there is no indication that in-combination effects associated with increased vessel traffic would result in a permanent shift in the population or the distribution of the grey seal feature within this SAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this SAC.

The Southern North Sea cSAC

6.7.2.61 Based on the information presented above, there is no indication that in-combination effects associated with increased vessel traffic would lead to a reduction in the viability of the harbour porpoise feature or adversely impact the supporting habitats and processes relevant to this species and their prey from being maintained and there is no indication that effects would result in a permanent shift in the distribution of the feature within this cSAC in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis, there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

6.7.2.62 Based on the information presented above and with respect to the Conservation Objectives for this SCI there is no indication that in-combination effects associated with increased vessel traffic would result in a reduction in the extent or quality of the habitat in order to maintain the feature population and there is no indication that effects would result in a permanent shift in the population or the distribution of the features within this SCI in the long term. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis, there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

6.7.2.63 Based on the information presented above and with respect to the Conservation Objectives for the SCI, there is no indication that that in-combination effects associated with increased vessel traffic on the harbour and grey seal features of this site would prevent the favourable conservation status of the qualifying species from being maintained. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis, there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

6.7.2.64 Based on the information presented above and with respect to the Conservation Objectives for the SAC potentially impacted, in-combination effects associated with increased vessel traffic would not prevent the extent and quality of habitat in order to maintain the population from being maintained. Nor is there any indication that this impact in-combination with other plans and projects would adversely affect any other factors which are required to ensure that the site is maintained in favourable condition as defined in the Conservation Objectives of this site. On this basis, there is no indication of an adverse effect on the Annex II qualifying feature of this SAC/SCI.

6.8 Summary

6.8.1.1 The screening process indicated that LSE on the interest features of the Wash and North Norfolk SAC, the Humber Estuary SAC, the Southern North Sea cSAC, the Klaverbank SCI, the Doggersbank SCI, and the Noordzeekustzone SAC/ Noordzeekustzone II SCI could not be discounted and so a systematic assessment of the potential for an adverse effect on the integrity of these sites has been undertaken.

6.8.1.2 The assessment has considered the potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects with respect to the sites Conservation Objectives.

6.8.1.3 With respect to those objectives, there is no indication, at this stage, that Hornsea Three, alone or in-combination with other plans and projects would prevent the maintenance or restoration of Annex II marine mammal features, habitats or supporting habitats, for which the sites are designated.

6.8.1.4 On this basis, there is no indication of an adverse effect on any of the any of the designated sites listed above.

6.8.1.5 These conclusions are summarised in Table 6.31 below.

Table 6.31: Summary of conclusions of AEoI alone and in combination with other plans and projects: Annex II marine mammal features.

Site	Feature	Project phase	Potential impact	Conclusion of AEoI from Project alone	Conclusion of AEoI from in-combination with other plans and projects
The Wash and North Norfolk Coast SAC	• Harbour seal	Construction/Decommissioning	• Underwater noise piling • Underwater noise UXO clearance • Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
Doggersbank SCI (Dutch designation)	• Harbour seal • Grey seal	Construction/Decommissioning	• Underwater noise piling • Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
Klaverbank SCI	• Harbour seal • Grey seal • Harbour porpoise	Construction/Decommissioning	• Underwater noise piling • Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
Humber Estuary SAC/Ramsar	• Grey seal	Construction/Decommissioning	• Underwater noise piling • Underwater noise UXO clearance • Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
Berwickshire and North Northumberland Coast SAC	• Grey seal	Construction/Decommissioning	• Underwater noise piling • Underwater noise UXO clearance • Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
Noordzeekustzone SAC/ Noordzeekustzone II SCI	• Grey seal	Construction/Decommissioning	• Underwater noise piling • Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated

Site	Feature	Project phase	Potential impact	Conclusion of AEoI from Project alone	Conclusion of AEoI from in-combination with other plans and projects
Southern North Sea cSAC	• Harbour porpoise	Construction/Decommissioning	• Underwater noise piling • Underwater noise UXO clearance	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
			• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events	An adverse effect on site integrity is not anticipated	An adverse effect on site integrity is not anticipated

7. Assessment of Adverse Effects on Integrity: offshore ornithology

7.1 Introduction

7.1.1.1 The screening exercise (stage 1 of the HRA process) identified potential for LSEs on the offshore ornithological features of the sites listed in Table 7.1 and shown in Figure 7.1.

7.1.1.2 This Report to Inform Appropriate Assessment has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2016) and the final version following consultation and completion of the ongoing EIA will be submitted as part of the application for Development Consent.

7.1.1.3 The screening report followed Natural England's guidance note regarding screening for SPA features in the non-breeding season (JNCC & Natural England, 2013). This approach defined Biologically Defined Minimum Population Scales (BDMPS) for each species outside of the breeding season.

7.1.1.4 The final assessment for each effect is based upon expert judgement.

7.2 Conservation Objectives

7.2.1.1 The AA component of HRA determines whether a proposed project has implications for a designated site's conservation objectives. All six of the SPAs identified in Table 7.1 have identical conservation objectives, however for FFC pSPA and the Greater Wash pSPA these represent draft objectives until the SPA is fully designated. The conservation objectives for UK SPAs are:

With regard to the potential SPA and the individual species and/or assemblage of species for which the site may be 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 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.*

7.3 Potential impacts

7.3.1 Overview

7.3.1.1 The screening exercise identified the potential for LSEs on offshore bird features in relation to the impacts detailed in Table 7.1. The potential impacts from Hornsea Three on offshore ornithological features are detailed in Table 7.2. Further information relating to the selection of species for consideration as part of displacement and collision risk analyses in provided in Environmental Statement volume 5, annex 5.2: Analysis of Displacement Impacts on Seabirds and Environmental Statement volume 5, annex 5.3: Collision Risk Modelling.

Table 7.1: European sites and features for which LSE have been identified – offshore birds

Site	Feature	Project phase	Effect
Greater Wash pSPA	Red-throated diver Common scoter	Construction/ decommissioning	Disturbance
		Operation	Displacement
	Sandwich tern	Construction/ decommissioning	Disturbance Changes to prey availability
FFC pSPA Flamborough Head and Bempton Cliffs SPA	Gannet (breeding, pre-breeding and post-breeding season)	Operation	Collision risk Displacement
	Kittiwake (breeding, pre-breeding and post-breeding seasons)	Operation	Collision risk
	Puffin (breeding season (immature birds) non-breeding season (all birds))	Construction/ decommissioning	Disturbance
		Operation	Displacement
	Guillemot (breeding season (immature birds) non-breeding season (all birds))	Construction/ decommissioning	Disturbance
		Operation	Displacement
	Razorbill (breeding season (immature birds) non-breeding seasons (all birds))	Construction/ decommissioning	Disturbance
		Operation	Displacement
Coquet Island SPA	Fulmar (breeding, post-breeding, non-breeding and pre-breeding seasons)	Operation	Displacement
Farne Islands SPA	Fulmar (breeding, post-breeding, non-breeding and pre-breeding seasons)	Operation	Displacement
Forth Islands SPA	Fulmar (breeding, post-breeding, non-breeding and pre-breeding seasons)	Operation	Displacement

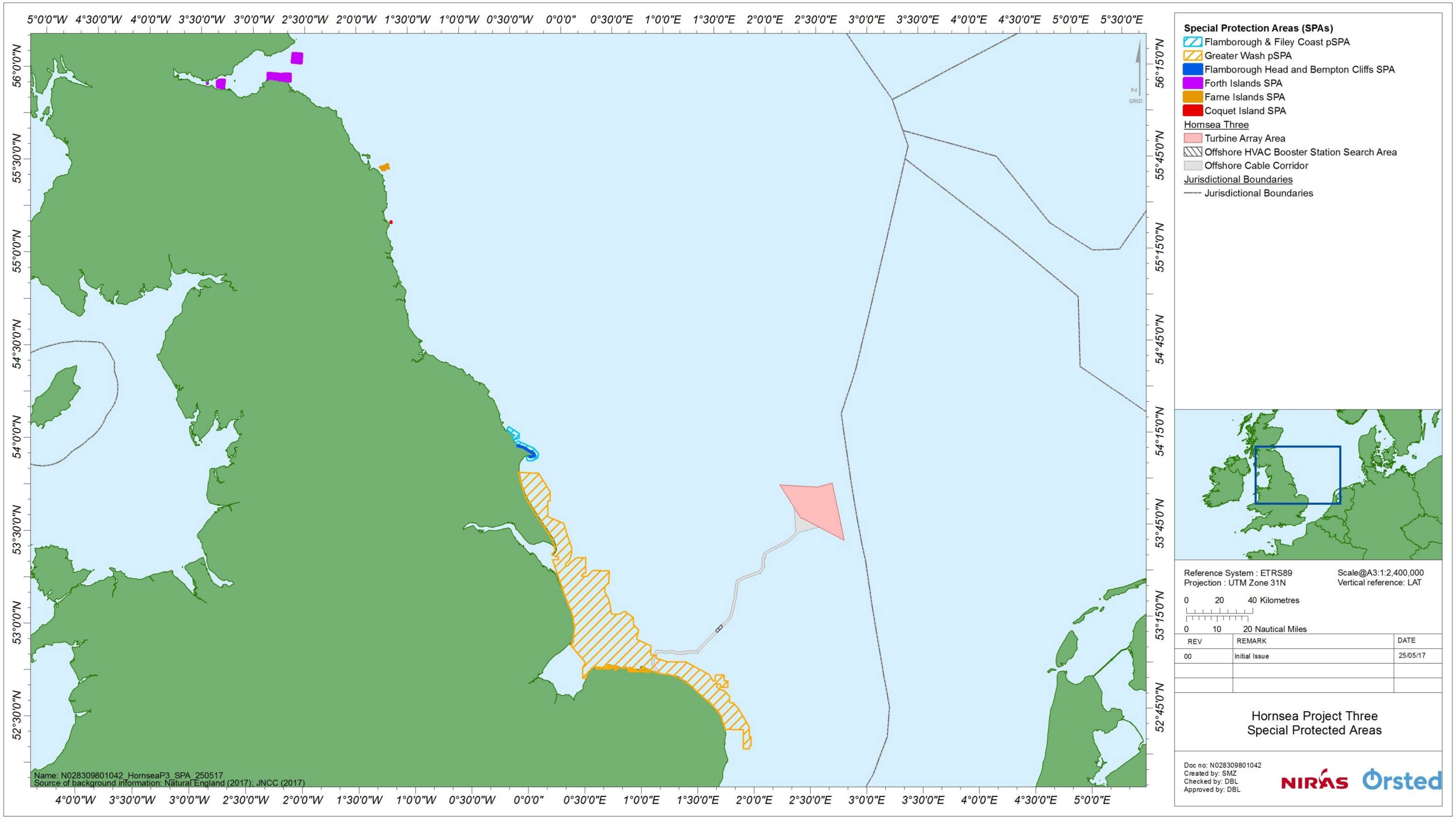


Figure 7.1: Sites with offshore bird features identified for AA.

Table 7.2: Potential Impacts from Hornsea Three on offshore ornithological site features.

Project phase	Potential impact	Justification
Construction	Direct temporary habitat loss/disturbance	The impact of construction activities such as increased vessel activity and underwater noise may result in direct disturbance or displacement of birds from important feeding and roosting areas.
	Changes to prey availability (indirect impact)	The impact of construction activities such as increased vessel activity and underwater noise may result in disturbance or displacement of prey from important bird feeding areas.
Operation/maintenance	Permanent habitat loss/disturbance	The impact of physical displacement from an area around turbines and other ancillary structures during the operational phase of the development may result in effective habitat loss and reduction in species survival rates and fitness. No permanent habitat loss within the intertidal zone is predicted.
	Collision	Collisions with rotating turbine blades will result in direct mortality of an individual. Increased mortality may reduce species' survival rates.
	Temporary habitat loss/disturbance	The impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of birds.
Decommissioning	Effects are assumed to be similar to those predicted during the construction phase	

7.3.2 Displacement analysis

7.3.2.1 The presence of wind turbines has the potential to directly disturb and displace birds from within and around Hornsea Three. This indirect habitat loss could reduce the area available for feeding, loafing and moulting for seabird species that may occur at Hornsea Three. In addition, there is the potential for seabird species to be affected by disturbance impacts resulting from construction, decommissioning and operation and maintenance activities associated with the Hornsea Three export cable route.

7.3.2.2 Seabird species vary in their reactions to the presence of operational infrastructure (e.g. wind turbines, substations and met mast) and to the maintenance activities that are associated with it (particularly ship and helicopter traffic). Wade *et al*. (2016) present a scoring system for such disturbance factors, which is used widely in offshore wind farm EIAs.

7.3.2.3 Following recently published joint SNCB interim guidance JNCC *et al*. (2017); displacement impacts for each relevant species are presented using a wide range of potential displacement and mortality rates. These have been presented as separate matrix tables, one for each of the seasons being assessed (e.g. 'breeding', 'post-breeding', 'non-breeding' and 'pre-breeding') in Environmental Statement volume 5, annex 5.2: Analysis of Displacement Impacts on Seabirds. The matrices and assessments presented in this RIAA take into consideration three species-specific factors: (i) intensity of displacement within a given area (i.e. what proportion of the population is displaced); (ii) spatial extent – to what distance from turbines any individuals within the population will be displaced; and (iii) seasonality – what magnitude of impact there will be within a population (taken as percentage mortality), based on the species' particular sensitivity during a particular stage in the life cycle.

7.3.2.4 It is recognised that for many species, limited information is available to predict the magnitude of displacement or, should it occur, its resultant effects on populations. For most species there has been little evidence of total or near-total displacement from constructed offshore wind farms (e.g., Krijgsveld *et al*., 2011). For some species, such as auks, the reported levels of displacement have been variable (see paragraphs 7.3.2.13 to 7.3.2.39).

Species for consideration

7.3.2.5 Environmental Statement volume 5, annex 5.2: Analysis of Displacement Impacts on Seabirds presents information to inform the assessments presented in this chapter relating to the significance of displacement impacts. These analyses have been informed by recent guidance published jointly by the UK SNCBs (JNCC *et al*., 2017).

7.3.2.6 The full process applied to identify species that may be impacted by displacement effects is documented in the Baseline Characterisation Report (Environmental Statement volume 5, annex 5.1: Offshore Ornithology Baseline Characterisation Report).

7.3.2.7 The following features of the SPAs screened into this RIAA were identified for inclusion in the displacement assessment for potential displacement impacts associated with the Hornsea Three array area:

- Fulmar;
- Gannet;
- Puffin
- Razorbill; and
- Guillemot.

7.3.2.8 In addition, potential disturbance/displacement impacts associated with the export cable route have been considered for three features of the Greater Wash pSPA, red-throated diver, common scoter and Sandwich tern.

Spatial scales

7.3.2.9 JNCC *et al.* (2017) recommends that for the species of highest sensitivity (divers and sea ducks), the array area plus 4 km buffer should be used when assessing displacement, whereas a 2 km buffer should be used for all other species. In both cases JNCC *et al.* (2017) recommended that no gradient in the displacement impact should be applied to the buffer zone, as there is not sufficient evidence to underpin any such application on a species-by-species basis. This is a precautionary approach as it is accepted that some degree of gradient will likely occur in respect to how seabirds are influenced by disturbance with factors such as past exposure to the event (habituation), the need to feed chicks and ability to forage as successfully elsewhere being considered to have an influence.

7.3.2.10 For all species included in the displacement analysis, the Hornsea Three array area plus a 2 km buffer around the Hornsea Three array area is used with no gradient in the displacement impact applied to the buffer zone. Species deemed particularly sensitive to displacement, such as divers and seaduck did not qualify as VORs in this assessment for the Hornsea Three array area due to either being absent (e.g. common scoter) or recorded in only very small numbers (e.g. red-throated diver) during site-specific aerial surveys (Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report). Red-throated diver and common scoter did however qualify as VORs for consideration in relation to impacts arising from the Hornsea Three Export Cable Route with a 2 km buffer which is considered to be an equally valid spatial extent to consider disturbance / displacement impacts due to low densities of birds and the nature of the potential impacts.

7.3.2.11 Seasonal mean-peak population estimates of birds at Hornsea Three plus a 2 km buffer have been applied in order to assess displacement effects. Joint SNCB advice recommends the use of mean-peak population estimates for displacement analysis (JNCC *et al*., 2017).

7.3.2.12 Displacement effects associated with the Hornsea Three Export Cable Route have been assessed using a seasonal mean-peak population derived from existing datasets (Lawson *et al.,* 2015). This approach has considerable elements of precaution as the spatial extent of the data is limited to inshore areas where the highest density of relevant species is likely to occur and the nature of potential impacts, which are likely to be of a lesser magnitude when compared to displacement impacts associated with the array area.

Displacement and mortality rates

Overview

7.3.2.13 The potential impact of displacement will vary depending on the season. Breeding seabirds are 'central place foragers', with the need to optimise their time spent away from the nest and energy expended in foraging. The range at which they can forage away from the nest site becomes constrained by distance from their nesting site, unlike birds that are not actively breeding, irrespective of season, that can forage more widely. Consequently, displacement during the breeding season of breeding adults from foraging areas is predicted to have a greater magnitude of impact than at other times as birds may struggle to meet their energy requirements.

7.3.2.14 JNCC *et al.* (2017) indicates that SNCBs intend to use 'Disturbance Susceptibility' scores from Bradbury *et al.* (2014) (which have in fact been updated by Wade *et al.* (2016)) as a general guide to the appropriate displacement levels to apply for a species. JNCC *et al.* (2017) suggests that displacement rate of 90-100% should be used for species with a high vulnerability, 30-70% should be used for species with a moderate vulnerability and 10% should be used for species with a low vulnerability. In addition, where possible, attempts have been made to refine these rates using available published evidence. This has been brought together and summarised in the following section.

Review of displacement rates

7.3.2.15 Although concentrating on birds in flight, the study of the operational Egmond aan Zee wind farm by Krijgsveld *et al*. (2011) represents one of the more in-depth studies to date on determining the effect of the presence of operational turbines on birds. Based on radar and panorama scans, macro-avoidance rates (i.e. birds avoiding the wind farm as a whole) were assessed for the majority of species groups present, and this behaviour is likely to be indicative of displacement risks. Gulls were the main species present, and although in the cases of auks and divers too few observations were available to obtain a reliable macro-avoidance rate, from flight paths it was evident that their avoidance behaviour was similar to that of gannets and scoters, rather than that of gulls.

7.3.2.16 Construction period records from the Lincs offshore wind farm showed that at least 769 birds (198 observations) including large gulls, kittiwake and terns used turbine bases and monopiles to rest on. On several occasions gulls were clearly associated with the jack-up barge, the guard vessels and with the construction vessel while piling was in progress (RPS, 2012). Similarly, Vanermen *et al.* (2013) in their study of Belgian offshore wind farms, observed that birds (mainly gulls) were attracted to physical structures e.g. turbines, as roost locations and did not show any signs of displacement. Construction disturbance to these species is therefore considered likely to be minimal.

Fulmar

7.3.2.17 Fulmar is considered to have a very low vulnerability to displacement from offshore wind farms, being assigned a score of 1 (out of 5) by Wade *et al*. (2016). JNCC *et al*. (2017) suggests that a 10% displacement rate would be assumed for species such as fulmar.

7.3.2.18 There was no significant effect on the abundance of fulmar at the Thortonbank offshore wind farm between the pre-construction and operational phases (Vanerman *et al.,* 2017). Leopold *et al.* (2011) were unable to draw conclusive results at Egmond aan Zee due to low numbers of birds although Krijgsveld *et al*. (2011), using data collected at the same project, identified fulmar as a lower sensitivity species with a displacement rate of 28%. Barton *et al.* (2009) noted "*highly significant*" declines in the abundance of fulmar at the Arklow Bank wind farm although declines appear to have occurred across the entire study area.

7.3.2.19 Available published evidence for fulmar is limited and as such it is considered appropriate to consider a range of displacement rates from 10-30%.

Gannet

7.3.2.20 Gannet is considered to have a high vulnerability to displacement from offshore wind farms, being assigned a score of 4 (out of 5) by Wade *et al*. (2016). JNCC *et al.* (2017) however quote Bradbury *et al* (2014) who score gannets susceptibility to disturbance as 2 (out of 5). Considering that JNCC *et al.* (2017) suggests that a 30-70% displacement rate range would be appropriate for guillemot and razorbill (rated 3 out of 5 for disturbance susceptibility) it is assumed here that a similar range would be appropriate (and precautionary) for gannet.

7.3.2.21 Krijgsveld *et al*. (2010; 2011) have shown that gannets in flight strongly avoid wind farms, albeit they do so relatively close to turbines (within 500 m) resulting in a macro-avoidance rate of 64%. Only small numbers of gannet were recorded at the Robin Rigg offshore wind farm increasing the uncertainty associated with the conclusions drawn however, there was potential avoidance of the wind farm during operation (Nelson *et al*., 2015).

7.3.2.22 Vanerman *et al.* (2017) found gannet showed significant avoidance of the Thorntonbank wind farm with numbers dropping 97% in the wind farm plus 500 m buffer area and a 70% reduction in the wind farm plus 3 km buffer. At the Blighbank wind farm plus a 500 m buffer, an 82% reduction was noted. When the effect in a 3 km buffer zone around Blighbank was considered a 26% reduction was noted, an effect which was not significant (Vanerman *et al.,* 2016). Significant avoidance of wind farms by gannet in Dutch waters has also been recorded with birds rarely entering the wind farm area but still observed flying around the wind farms (Leopold *et al*., 2011). In German waters, the abundance of gannet at the Alpha Ventus wind farm decreased between pre-construction and operation (Mendel et al., 2014) although information presented in Mendel *et al*. (2014) would suggest such decreases were a wider trend that was not limited to the wind farm area.

7.3.2.23 Although displacement rates for wind farm areas appear to be very high (approaching 100%), gannet are still observed within associated buffer areas. When including a 3 km buffer area, an overall 70% reduction was noted at Thortonbank with a 26% reduction at Blighbank wind farm. In addition, Krijgsveld *et al*. (2011) calculated a macro-avoidance rate of 64%. As such, a displacement rate range of 30-70% from the Hornsea Three array area plus 2 km buffer during the breeding and non-breeding seasons (post-breeding and pre-breeding seasons) is considered appropriate for the impact assessment for gannet.

Auks

7.3.2.24 Guillemot and razorbill are considered to have a high vulnerability to displacement from offshore wind farms, being assigned a score of 4 (out of 5) by Wade *et al*. (2016). JNCC *et al*. (2017) suggests that SNCBs would typically recommend a 30-70% displacement rate range for guillemot and razorbill based on disturbance susceptibility scores of 3 (out of 5). Puffin scores 2 (out of 5) for disturbance susceptibility, so the 30-70% range of displacement would apply in a precautionary sense to this species.

7.3.2.25 Krijgsveld *et al*. (2011) identified auks as higher sensitivity species to displacement calculating a macro-avoidance rate of 68% however, only relatively close to turbines (within 500 m). Dierschke and Garthe (2006) present evidence that also suggests guillemot and razorbill have a relatively high sensitivity to displacement from offshore wind farms. Danish studies at Horns Rev, whilst showing considerable variability, also suggest this, noting total absence from the wind farm footprint following construction (Petersen *et al*., 2006).

7.3.2.26 Studies undertaken at Dutch wind farms have reported displacement effects of less than 50% (Leopold *et al*., 2011). Leopold *et al*. (2010) found that at Egmond aan Zee, auks enter the wind farm area by swimming, and birds regularly foraged within the site. However, a number of more recent studies have not shown a similar level of impact. Arklow Bank Offshore Wind Farm did not find any significant difference in the number of guillemots present pre- and post-construction with an increase in the abundance of razorbill suggesting no impact due to the presence of turbines (Barton *et al*., 2009). Post construction monitoring at North Hoyle Offshore Wind Farm indicated an increase of up to 55% in the number of guillemots present compared to before the wind farm was constructed (nPower, 2008).

7.3.2.27 The abundance of razorbill at the Robin Rigg offshore wind farm was not significantly affected by the development phase of the wind farm, although densities of razorbill on the sea did increase within the wind farm area between the pre-construction and operational phases (Nelson *et al*., 2015). The abundance of guillemot at the same wind farm was significantly affected by the development phase of the wind farm, increasing between pre-construction and operation.

7.3.2.28 The abundance of guillemot at the Thortonbank offshore wind farm was shown to have decreased significantly once the wind farm was operational (69% in the wind farm plus 500 m buffer area). Although decreases were also noted in the buffer area (500 m to 3 km) these were not statistically significant. The abundance of razorbill decreased within the wind farm area but increased in the surrounding buffer. When these two areas were combined there was no apparent effect on the abundance of razorbill due to the presence of the wind farm (Vanerman *et al*., 2017). Similar results were found at the Alpha Ventus offshore wind farm with the abundance of guillemot significantly lower after the construction of the wind farm (Mendel *et al*., 2014). At Blighbank offshore wind farm both guillemot and razorbill appeared to avoid the wind farm area with decreases of 75% and 67%, respectively however, decreases were lower (and not significant) in the buffer area (49 and 32%, respectively) (Vanerman *et al*., 2016).

7.3.2.29 It is important to note that some of the high displacement rates reported in the studies summarised here apply to the wind farm alone whereas the displacement analyses for Hornsea Three calculate the number of birds displaced from Hornsea Three plus a 2 km buffer. A number of studies found no significant effect on the number of birds present in buffer areas around wind farms and therefore the likely displacement rate is not considered to be at the upper end of the range considered.

7.3.2.30 Monitoring studies have often recorded auks inside wind farm areas and on the basis of the above information, a displacement value of 50% has been used for guillemots based on the conclusions of Vanerman *et al*. (2016; 2017) and Nelson *et al*. (2015), in particular. Based on the studies summarized above, razorbill appears to have a lower vulnerability to displacement impacts than guillemot, especially when considering the results obtained at Thortonbank (Vanerman *et al*., 2017), Blighbank (Vanerman *et al*., 2016) and Robin Rigg (Nelson *et al*., 2015) which show lower displacement rates than those calculated for guillemot. As such, a displacement rate of 40% is considered appropriate for razorbill.

7.3.2.31 There have been few studies which have included puffin as a separate species to assess displacement rates, with the majority combining all auks together. For assessment purposes, a displacement value of 50% from the Hornsea Three array area plus 2 km buffer during the breeding and non-breeding seasons is considered appropriate for puffin, based on the rationale described for razorbill, but with an added degree of precaution due to a lower level of empirical evidence.

Review of mortality rates

7.3.2.32 There is limited evidence on what the extent of the impact magnitude may be, although a typical ceiling of 10% is often applied by SNCBs (e.g. see the assessments produced for Hornsea Project Two (Natural England, 2015a; 2015b; 2015c)). There are no directly appropriate studies of the effects of displacement on mortality of seabirds. It is however reasonable to consider as overly precautionary, the assumption of 100% of displaced birds will die. It follows that the density of birds within areas to which birds are displaced will increase as a result of the relocation of the displaced birds to where others may already be occupying. There is the possibility that there will be additional mortality experienced by these birds due to increased resource competition and that this “additional mortality” will be a function of density (i.e. the mortality rate increases as density increases).

7.3.2.33 When assessing the resultant effects of displacement on a population, previously a common starting default position has been the worst-case scenario of 100% mortality for displaced birds. However, this is now recognised throughout the offshore wind industry and SNCBs as being unrealistic and over-precautionary (for example see Natural England, 2015a; 2015b; 2015c; and MS-LOT, 2017).

7.3.2.34 Based on expert judgment on the sensitivity of each receptor, for the purposes of the assessment precautionary mortality rates of between 2 and 10% are applied to displaced species taken forward to impact assessment. These rates are comparable to those previously used in offshore wind farms (e.g. Hornsea Project Two). However, recent advice provided by Scottish Natural Heritage (SNH) for projects in Scottish waters has proposed mortality rates of 2% for puffin and 1% for guillemot and razorbill across all seasons, while as part of the same process the RSPB advised a 2% mortality rate for all species for all seasons.

7.3.2.35 Mortality rates vary between species, with actual assigned values dependent on that species’ known behaviour (e.g. habitat and foraging flexibility as defined in Wade *et al.,* 2016). These rates are considered suitably precautionary for the purposes required here, although the matrices presented show rates of up to 100% for both displacement and mortality as recommended in interim guidance (JNCC *et al.*, 2017).

7.3.2.36 Fulmar and gannet have extensive foraging ranges during the breeding season (Thaxter *et al.* 2012) providing the species with sufficient alternative foraging opportunities. A mortality rate of 2% is therefore considered appropriate in the breeding season. For the three auk species, it is considered highly unlikely that any breeding adult birds will be present at Hornsea Three with the population present considered to be composed of immature and non-breeding birds. These birds are not constrained due to the necessity to provision young and therefore the application of a lower mortality rate in the breeding season for these species may be appropriate. In addition, Hornsea Three is located in an area of the North Sea that does not support high densities of the three auk species in any season (see annex 5.1: Baseline Characterisation Report). Therefore the application of a range of mortality rates (2-10%) is considered appropriate for the three auk species in the breeding season.

7.3.2.37 During the ‘non-breeding’ periods (defined here as all seasons outside of the breeding season), seabirds are generally less constrained in terms of the foraging areas they can use and are more capable of relocating to other areas. Birds that were breeding adults are not constrained by central place foraging from a colony and therefore have a greater degree of flexibility in utilising different resources free from providing food for young or breeding partners. The vast majority of individuals are therefore highly likely to find alternative foraging habitat if displaced. However, for the purposes of this assessment it is considered that in the non-breeding season, a significantly lower proportion of birds will be exposed to sufficient stress to suffer mortality. Therefore, a mortality rate of 1% of displaced birds has been adopted and is considered suitably precautionary

7.3.2.38 ‘Post-breeding’ seabirds leave their colonies and disperse. For most species this period is little or no different from the ‘non-breeding’ period. However, razorbill and guillemot, for example, leaving their colonies accompanied by chicks are constrained to some extent, by both the adults and young being flightless and therefore unable to travel large distances rapidly in search for food. Displaced birds away from suitable foraging areas may be at higher risk of increased mortality than birds during the ‘non-breeding period’. Other post-breeding seabirds can, however, move further afield than breeding adults and therefore the potential effects from displacement are expected to be lower. Furthermore, the possible impacts from displacement are more transitory as the majority of birds are dispersing through the area. For the purposes of the assessment a 2% mortality rate for auks displaced in the post-breeding period is applied, which reflects the lower restrictions than during the breeding season, but the slightly increased potential for mortality on these species due to the ongoing care required for young, as well as any stress incurred during the moult period when foraging range is more limited.

Summary

7.3.2.39 Table 7.3 summarises the proposed displacement and mortality rates to be considered in relevant assessments based on the information presented above.

Table 7.3: Assessment criteria for displacement effects for the area Hornsea Three array area plus a 2 km buffer

Species	Season of relevance	Months	Displacement rate based on guidance interpreting Wade *et al.* (2016) sensitivity scores (%)	Evidence – based displacement rate (%)	Mortality rate (%)
Fulmar	Breeding	Apr – Aug	10	10-30	2
	Post-breeding	Sep-Oct			1
	Non-breeding	Dec			1
	Pre-breeding	Jan – Mar			1
Gannet	Breeding	Apr – Aug	30-70	30-70	2
	Post-breeding	Sep – Nov			1
	Pre-breeding	Dec- Mar			1
Puffin	Breeding	Apr – Jul	30-70	50	2-10
	Non-breeding	Aug – Mar			1
Razorbill	Breeding	Apr – Jul	30-70	40	2-10
	Post-breeding	Sep – Oct			2
	Non-breeding	Nov – Dec			1
	Pre-breeding	Jan – Mar			2
Guillemot	Breeding	Mar – Jul	30-70	50	2-10
	Non-breeding	Aug – Feb			1

7.3.3 Collision Risk Modelling

7.3.3.1 Collision Risk Modelling (CRM) was undertaken to quantify the potential risk of additional mortality through collisions with operational turbines above the current baseline for each species. The most frequently used collision risk model in the UK is commonly referred to as 'the Band model'. This model was originally devised in 1995 and has since been subject to a number of iterations, most recently to facilitate application in the offshore environment (Band, 2011) and to allow for the use of flight height distribution data and to include a methodology for considering birds on migration (Band, 2012).

7.3.3.2 Masden (2015) presents an update to Band (2012) which further develops the application of the Band model using a simulation modelling approach to incorporate variability and uncertainty. The update provides for an improved understanding of uncertainty by randomly sampling parameter values from distributions for each parameter, deriving average collision risk estimates with associated measures of variability. However, it has recently come to light through advice from Natural England that further amendment of the Masden (2015) update of the collision risk model is required before they advise its use. As a result, Masden (2015) has not been used to calculate collision risk estimates for Hornsea Three.

7.3.3.3 In order to express the uncertainty associated with the collision risk estimates used in the assessment, modelling has been conducted incorporating upper and lower confidence intervals associated with species densities and flight height distributions.

7.3.3.4 The Band (2012) model incorporates two approaches to calculating the risk of collision referred to as the 'Basic' and 'Extended' versions of the model. A key difference between these versions is the extent to which they account for the flight height patterns of seabirds (Band 2012). The distribution of seabird flights across the sea is generally skewed towards lower altitudes. As stated by Band (2012) there are three consequences of a skewed flight height distribution:

- *"the proportion of birds flying at risk height decreases as the height of the rotor is increased;*
- *more birds miss the rotor, where flights lie close to the bottom of the circle presented by the rotor; and*
- *the collision risk, for birds passing through the lower parts of a rotor, is less than the average collision risk for the whole rotor."*

7.3.3.5 The Basic model assumes a uniform distribution of flights across the rotor with a consistent risk of collision across the whole rotor swept area. The Extended model of Band (2012) takes into account the distribution of birds in addition to the differential risk across the rotor swept area. It should be noted that the use of the basic model is precautionary as it does not take into account the variability in risk of collision that occurs across a rotor swept area, with the risk of collision decreasing as the distance from the hub of the turbine increases. If this were to be taken into account (as when using Option 3) it is likely that collision risk estimates would be lower as the vertical distribution of birds flying across water is skewed towards lower heights (i.e. those associated with a lower risk of collision within a rotor swept area).

7.3.3.6 Both the Basic and Extended models of Band (2012) allow for the use of two 'Options' termed Options 1-4. Options 1 and 2 use the Basic model with Options 3 and 4 utilising the Extended model. The difference between the two Options under each model is linked to the use of flight height data. Options 2 and 3 use generic data from Johnston *et al.* (2014) whereas Options 1 and 4 use site-specific data derived from site-specific surveys.

7.3.3.7 The flight height data collected as part of site-specific digital aerial surveys at Hornsea Three have been thoroughly reviewed and are concluded to be of limited use in collision risk modelling (see Consultation Report, Annex 1 Evidence Plan for EWG discussion in relation to this point). For the majority of species the number of records falls below a 100 record threshold which has been recommended as being required by Natural England in order to calculate a representative PCH value (Natural England, 2013). For those two species for which a representative PCH value is calculable, the resulting value falls considerably outside of the confidence limits associated with generic flight height information (Johnston *et al*., 2014); no valid ecological reason has been identified as to why this should occur.

7.3.3.8 Further to this, the majority of records in the dataset have associated wide confidence intervals and there are a significant number of records that are assigned a negative flight height. Of the 3,553 records of birds recorded in flight between April 2016 and September 2017 (flight heights were not calculated for birds recorded in the October or November 2017 surveys) a height value could be estimated for just over 39% (1,393 birds). Of these birds, a negative flight height was estimated for over 29%. For those birds for which a positive flight height was estimated (987 records) the lower confidence limit for 38% was also negative. This therefore leaves only 538 records that are unaffected by negative values, which represents a limited dataset that could not robustly inform the assessment. Uncertainties remain associated with potential issues relating to the methodology used to obtain flight heights during digital aerial surveys and as such these data have not been used to inform collision risk modelling for Hornsea Three.

7.3.3.9 To populate assessment of collision risk, various options have been considered in the absence of adequate data from the digital aerial survey programme. It is considered that data that has direct relevance to Hornsea Three would be preferable and indeed, there exists a considerable amount of flight height data that were collected during boat-based surveys conducted to support the application process for the Hornsea Project One and Hornsea Project Two offshore wind farms. Surveys were conducted between March 2010 and February 2013 covering the former Hornsea Zone and were based on standard survey methodologies (Camphuysen *et al*., 2004). A full description of the surveys conducted is presented in SMart Wind (2015a) and SMart Wind (2013). These data have been interrogated in order to identify those records that occur within Hornsea Three plus a 4 km buffer.

7.3.3.10 The boat-based surveys undertaken for the Hornsea Project One and Hornsea Project Two offshore wind farm applications categorised flying birds into five metre height bands meaning that, for example, birds assigned to the 10 m flight height band were flying between 7.5 and 12.5 m. The lower rotor tip height at Hornsea Three is 33.17 m (MSL); therefore the 35 metre flight height band (32.5 – 37.5 m) has been used to calculate the proportion of birds at PCH. Although likely to include a proportion of birds that are actually outside of the rotor swept area (i.e. those between 32.5 and 33.17 m), the use of a complete five metre band is considered precautionary and aligns with the approach to analysis requested by Natural England during the examination at Hornsea Project Two (see SMart Wind, 2015b). The PCH values calculated for each species are presented in Environmental Statement volume 5, annex 5.3: Collision Risk Modelling.

7.3.3.11 In addition to the use of Option 1 incorporating site-specific flight height data, collision risk estimates have been calculated using Options 2 and 3 of the Band (2012) model which make use of aggregated flight height data contained in Johnston *et al*. (2014). Collision risk estimates calculated using Options 2 and 3 are presented at the request of stakeholders during EWG meetings however, these Options are considered to over-estimate collision risk as they utilise flight height data that is not specific to Hornsea Three with this supported by the PCH values derived from boat-based data covering Hornsea Three used when modelling using Option 1. It is also important to note that Options 1 and 2, which use the Basic model of Band (2012) are also likely to over-estimate collision risk due to the simplistic assumptions associated with the Basic Band model.

7.3.3.12 A full description of the collision risk modelling methodology is provided in Environmental Statement volume 5, annex 5.3: Collision Risk Modelling.

7.3.3.13 The maximum design scenario for collision risk in this modelling process is taken to be the development scenario comprising the maximum number of turbines (300) with parameters as defined in volume 1, chapter 3: Project Description. The parameters for this scenario are presented in Environmental Statement volume 5, annex 5.3: Collision Risk Modelling. The collision risk modelling assumed a wind turbine hub-height of 116.77 m (above LAT) will be used at Hornsea Three. This provides for a minimum lower tip height clearance of 34.97 m LAT reducing the potential collision risk impacts to seabirds when compared to lower minimum lower tip heights.

7.3.3.14 Collision risk and displacement impacts have the potential to affect the same species of birds, with some receptors (e.g. gannet) deemed to be sensitive to both. The assumption is made here however that the two mechanisms act independently on different individual birds present at Hornsea Three. Critically, it is determined that birds displaced from the array site or buffer cannot be exposed to collision risk in an additive fashion. Therefore, it is not considered appropriate to sum predicted impacts of collision and displacement.

Collision risk to regularly occurring seabirds

7.3.3.15 Collision risk modelling was conducted for four regularly occurring seabird species at Hornsea Three including gannet and kittiwake that have been screened in for inclusion in this RIAA.

7.3.3.16 Collision risk modelling for these species has been conducted using the Band (2012) CRM. Bird biometric parameters for each of these species are presented in Environmental Statement volume 5, annex 5.3: Collision Risk Modelling.

7.3.3.17 The avoidance rates applied for each species are also presented in Environmental Statement volume 5, annex 5.3: Collision Risk Modelling. The rates applied are taken from Cook *et al*. (2014) which presents avoidance rates for gannet and kittiwake. Cook *et al*. (2014) recommended avoidance rates for use with the Basic model for gannet and kittiwake but were unable to recommend an avoidance rate for use in the Extended model for either of these species. As such, a default 98% avoidance rate is applied in the modelling conducted for Hornsea Three.

7.3.3.18 In a joint response, UK SNCBs supported the recommended avoidance rates of Cook *et al*. (2014) with the exception of kittiwake (JNCC *et al*., 2014). The SNCBs did not agree with the application of avoidance rates calculated for the 'small gull' category used in Cook *et al*. (2014) to kittiwake and recommended that the avoidance rate calculated for the 'all gull' category should be applied instead. Collision risk modelling for Hornsea Three is therefore conducted using the avoidance rates presented in Table 7.4 taking into account the recommendations in Cook *et al*. (2014) and JNCC *et al*. (2014).

Table 7.4: Avoidance rates applied in collision risk modelling for regularly occurring seabirds at Hornsea Three.

Band (2012) model	Gannet	Kittiwake
Basic	98.9 (±0.2)	98.9 (±0.2) 99.2 (±0.2)
Extended	98.0	98.0

7.3.3.19 Outputs from the collision risk modelling undertaken gannet and kittiwake are presented in Environmental Statement volume 5, annex 5.3: Collision Risk Modelling.

7.4 Baseline information

7.4.1 Evidence-based approach

7.4.1.1 Advice in relation to Hornsea Three specifically has been sought through consultation with the statutory consultees through the Evidence Plan process. The Evidence Plan process has been set out in the Evidence Plan (Consultation Report, Annex 1 Evidence Plan), the purpose of which is to agree the information Ørsted needs to supply, as part of a DCO application for Hornsea Three. This includes agreeing the methodology to inform the baseline. The Evidence Plan seeks to ensure compliance with the EIA and Habitat Regulations.

7.4.1.2 As part of the Evidence Plan process, an Offshore Ornithology EWG was established with representatives from the key regulatory bodies, SNCBs, including the MMO and Natural England, and non-statutory parties, including the RSPB. A number of meetings have been held in order to discuss and agree key elements of the offshore ornithology EIA. Meetings with key stakeholders commenced in March 2016 and have continued throughout 2016 and 2017.

7.4.1.3 The approach proposed by Ørsted for the purposes of characterising the offshore ornithology at Hornsea Three was an evidence based approach to the EIA, which includes utilising existing data and information from sufficiently similar or analogous studies to inform the baseline understanding and/or impact assessments for a new proposed development. The Hornsea Three array area is located within the former Hornsea Zone, for which extensive data and knowledge regarding offshore ornithology is already available. This data/knowledge has been acquired through zonal studies and from the surveys and characterisations undertaken for Hornsea Project One and Hornsea Project Two between 2010 and 2013. The suitability of existing ornithological data from across the Hornsea zone to inform the EIA, specifically regarding the array site, is being examined by means of a meta-analysis and reviewed by the EWG (further detailed in a section below).

7.4.1.4 The baseline characterisation of the Hornsea Three offshore ornithology study area (Hornsea Three array area and a 4 km buffer) has also drawn upon the site-specific surveys that have been undertaken (further detailed in section 7.4.4 below). The survey methodologies have been discussed with the EWG through the Evidence Plan process. The EWG have advised that two years of site specific data is required to characterise the baseline environment. However considering the timescale of the Project, the EWG have agreed that monthly aerial surveys from April 2016 – September 2017, supplemented by existing historical data, is the most appropriate approach to providing enough site specific data to characterise the baseline environment. The suitability of the existing ornithological data from across the former Hornsea Zone to inform the EIA, specifically regarding the array site, has been analysed in the form of a meta-analysis.

7.4.1.5 The Hornsea Three offshore cable corridor is unique to Hornsea Three. As such, the existing data and knowledge of the baseline environment along the offshore cable corridor for Hornsea Project One and Hornsea Project Two is relevant only in part to the Hornsea Three offshore cable corridor and the evidence-based approach described above cannot be applied. Therefore the baseline characterisation of the Hornsea Three offshore cable corridor has primarily drawn upon the desktop information from third-party surveys, including surveys targeting areas within and in close proximity to areas designated for nature conservation, primarily Lawson *et al.,* (2015). An initial desk based appraisal and site walkover in July 2016 at the Hornsea Three landfall area established the export cable corridor landfall being of minimal importance for intertidal birds (DONG Energy, 2016a). The EWG have agreed that no further intertidal surveys are required and the intertidal assessment will be incorporated into the offshore ornithology and onshore ecology assessments as required.

7.4.2 Identification of SPAs relevant to Hornsea Three

7.4.2.1 During the breeding season foraging birds may travel some distance from their breeding colonies. The information available on the distances that breeding birds will forage depends on the species. Thaxter *et al*. (2012) provide data on recorded foraging ranges for a wide range of species, including the mean and maximum distances travelled. Typically the mean-maximum range (i.e. the mean average of the maximum foraging trips recorded) has been used as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between a SPA breeding colony and a proposed wind farm array area. In some cases more specific information is available from GPS/satellite tracking studies, such as, for example, the FAME/STAR initiatives for kittiwake and gannet colonies associated with the FFC pSPA.

7.4.2.2 For the identification of SPAs relevant to Hornsea Three, mean-maximum foraging ranges (±1 SD) as reported by Thaxter *et al*. (2012) have been used to determine potential connectivity with Hornsea Three, unless specific relevant tracking data are available (where the latter is deemed to have priority). A full description of the process used to identify connectivity between features of FFC pSPA and Hornsea Three is provided in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA.

7.4.2.3 During the non-breeding period, birds from colonies further afield may also be present within Hornsea Three study area, although there is some uncertainty regarding how many individuals from each of the colonies will be affected by Hornsea Three. Details of how potential impacts are apportioned are given in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA.

7.4.3 Desktop study

7.4.3.1 A literature review was undertaken to provide information on the ornithological interest of the former Hornsea Zone and its importance in a regional, national and international context. This review included general seabird ecology, migration behaviour, population sizes and conservation status, particularly on the east coast of Britain, the southern North Sea, and Britain as a whole. Information sources used are summarised in Table 7.5.

Table 7.5: Summary of key desktop reports.

Title	Source	Year	Author
Data from aerial surveys carried out between 2004 and 2008 collated in reports produced by the Department of Energy and Climate Change (DECC, formerly BERR) and the Department for Trade and Industry (DTI)	DTI, 2006; BERR, 2007; DECC, 2009	Multiple	-
JNCC Online SPA standard data forms for Natura 2000 sites	http://jncc.defra.gov.uk/page-1400	Multiple	
Existing offshore wind farm Environmental Statements and Monitoring Reports	Multiple	Multiple	Multiple
Reports, guidance and advice notes	Scoping Response from Natural England	Multiple	Multiple
Wetland Bird Survey (WeBS) Annual Reports and Report Online interface	Wetland Bird Survey partnership	Multiple	Multiple
British Trust for Ornithology (BTO) online profiles of birds occurring in Britain and Ireland, BirdFacts	British Trust for Ornithology	2016	Robinson
Biologically appropriate, species-specific, geographically non-breeding season population estimates for seabirds	Natural England	2015	Furness
Population estimates of birds in Great Britain and the UK	British Birds journal	2013	Musgrove *et al.*
Seabird sensitivity mapping for English territorial waters	Natural England	2013	WWT Consulting and MacArthur Green Ltd
Survey data relating to the former Hornsea Zone, including Hornsea Project One and Hornsea Project Two boat based surveys	SMartWind	2010-2013	
Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas	British Trust for Ornithology	2012	Thaxter *et al.*
Assessing the risk of offshore wind farm development to migratory birds designated as features of UK SPAs	Strategic Ornithological Support Services	2012	Wright *et al.*
An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs	JNCC	2010	Kober *et al.*

Title	Source	Year	Author
A review of assessment methodologies for offshore wind farms	British Trust for Ornithology	2009	Maclean *et al.*
The Migration Atlas	British Trust for Ornithology	2002	Wernham *et al.*
Atlas of seabird distribution in northwest European waters	JNCC	1995	Stone *et al.*

7.4.4 Site specific surveys

Site-specific aerial surveys

7.4.4.1 For Hornsea Three, digital aerial surveys have also been undertaken between April 2016 and November 2017. These aerial surveys covered the Hornsea Three array area and a 4 km buffer. A strip-transect method was employed with transects arranged approximately perpendicular to depth contours and 2.5 km apart. Further information on the aerial digital survey methodology and how data are processed are described in Sections 1.2.1 and 1.2.2 of the Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report, respectively.

7.4.4.2 Data collected during aerial surveys were analysed by trained reviewers. The abundance of each species observed during surveys was estimated separately using a design-based strip transect analysis with variance and confidence intervals ("CI") derived using a bootstrapping methodology. A more detailed overview of the data processing approach and calculation of abundance metrics is provided in Section 1.2.3 of Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report.

7.4.4.3 It was agreed through the Offshore Ornithology EWG that surveys of the cable corridor were not required. A walkover survey of the intertidal habitat at the export cable landfall identified a narrow strip of cobble/shingle/sand which was considered to provide minimal opportunities for foraging and roosting by intertidal birds. It was therefore considered that there would be no impacts on intertidal bird species, a conclusion that was agreed within the EWG. Intertidal birds are consequently not considered for further assessment within this HRA.

Former Hornsea Zone Boat-based surveys

7.4.4.4 A series of monthly boat-based surveys of seabirds across the former Hornsea Zone commenced in March 2010 and were completed in February 2013, encompassing three breeding, migratory and winter periods.

7.4.4.5 JNCC was consulted in January 2010, on the proposed survey methodology for ornithology surveys across the former Hornsea Zone. This methodology was formally approved, as part of the PINS planning process, in the Scoping Opinions for Hornsea Project One (IPC, 2010) and Hornsea Project Two (The Planning Inspectorate, 2012). Full details of these surveys and the methodology employed are included in the Hornsea Project Two Ornithology Technical Report Part 1, Section 2 (see PINS Document Reference 7.5.5.1 available from https://infrastructure.planninginspectorate.gov.uk).

Meta-analysis of baseline ornithological data sets

7.4.4.6 The site-specific surveys for Hornsea Three have obtained data for twenty months, including two full breeding seasons for the majority of species. For the largely non-breeding period of December to March however, there are site-specific digital aerial survey data for only one year. This is considered to be of relatively minor consequence to impact assessment as for example, the coverage actually obtained is comparable to that achieved in most 2 year survey campaigns in offshore settings. It is also considered that reduced site-specific survey coverage in these months is of lesser importance than would have been the case, say, for the breeding season when direct connectivity to SPA colonies may be expected for some seabird species. The site-specific survey data, including for the period December – March are also supplemented with a detailed analysis of historical data obtained for the former Hornsea Zone, including the area occupied by Hornsea Three.

7.4.4.7 As part of the preparation of data for use in the ES and Report to Inform Appropriate Assessment for Hornsea Three, a detailed analysis of the boat-based and digital aerial data has been conducted in order to understand the inherent variability in the boat-based survey data and how this affects the compatibility of these historical boat-based data with digital aerial data (see Environmental Statement volume 5, annex 5.4: Data Hierarchy Report).

7.4.4.8 This analysis is intended to produce the following outputs:

- Seasonal density estimates for the Hornsea Three area (plus relevant buffers) for key species and seasons;
- Identification of the seasonal and annual variability in population density for key species for each analysis area;
- Investigation of suitable co-variates (such as sea temperature, bathymetry, distance from shore, chlorophyll a) that might explain observed variability in densities and flight heights; and
- Detailed analyses including statistical analysis and, where possible, predictive modelling.

7.4.4.9 The production of these outputs should allow for the following analyses to be conducted which in turn will inform discussions in relation to Hornsea Three:

- Identification of the extent of boat-based ornithological records across the Hornsea Three area;
- Characterisation of uncertainty in population estimates and density distribution;
- Comparison of population estimates for 10 key species for Hornsea Three with those derived for the Hornsea Project One and Hornsea Project Two sites;

- Analysis of the variability in patterns of observed flight heights across the former Hornsea Zone by season and year;
- Comparison of results of the boat-based and aerial surveys; and
- Discussion in relation to the implications of the above for collision risk modelling and displacement analysis.

7.4.4.10 The results of the above analyses are used to inform the assessments undertaken for Hornsea Three by identifying whether, in those months where only one survey was completed as part of the aerial survey programme for Hornsea Three, the data from aerial surveys captures the variability inherent in seabird populations. For months where two surveys have been conducted the aerial survey data are considered to adequately capture this variability. The process by which population estimates or densities are identified is presented in Environmental Statement volume 5, annex 5.4: Data Hierarchy Report. The abundance metrics used for displacement analyses and collision risk modelling are identified in Environmental Statement volume 5, annex 5.2: Analysis of Displacement Impacts on Seabirds and Environmental Statement volume 5, annex 5.3: Collision Risk Modelling.

7.4.5 Baseline Information

7.4.5.1 A summary of the current baseline for offshore ornithological features relevant to Hornsea Three is given below. Further detailed information each species can be found in the Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report.

Species accounts

7.4.5.2 The following species accounts summarise information on the identified bird features to be considered within the AA.

Common scoter

7.4.5.3 Common scoter is listed on Schedule 1 of the Wildlife and Countryside Act (1981, as amended) and is currently red-listed on the UK Birds of Conservation Concern list (Eaton et al., 2015).

7.4.5.4 An estimated 52 pairs of common scoter breed in the UK, with the majority of pairs found in the north and west of Scotland (Musgrove *et al*., 2013; Balmer *et al*., 2013). The wintering population around Britain has been estimated at 100,000 individuals (Musgrove *et al*., 2013) and the 1% threshold for national importance is 1,000 birds (Musgrove *et al*., 2011).

7.4.5.5 Common scoter is listed as a qualifying interest species in the non-breeding season for four SPAs and one potential SPA on the UK east coast: Firth of Forth SPA; Firth of Tay and Eden Estuary SPA; Lindisfarne SPA; The Wash SPA; and Greater Wash pSPA. The Greater Wash pSPA supports a discrete population of approximately 3,463 individuals or nearly 3.5% of the British wintering population, making the site the fifth most important site for non-breeding common scoter in the UK.

7.4.5.6 No common scoter were recorded in aerial surveys undertaken across Hornsea Three offshore ornithology study area. The recorded absence of common scoter in offshore areas is also evident in the results presented in Stone *et al.* (1995) with high densities of common scoter in inshore areas.

7.4.5.7 The Hornsea Three export cable route runs through the Greater Wash Area of Search making landfall at Weybourne on the north Norfolk coast, approximately 35 km east of the highest densities of common scoter within the mouth of The Wash. The average density of common scoter within the Hornsea Three offshore cable corridor, derived from Lawson *et al,* 2015, is consequently minimal and considerably less than 0.01 birds/km^2.

Red-throated diver

7.4.5.8 Red-throated diver is listed on Annex I of the EU Birds Directive (2009/147/EEC) and Schedule 1 of the Wildlife and Countryside Act (1981, as amended) and is currently green-listed on the UK Birds of Conservation Concern list (Eaton et al., 2015).

7.4.5.9 An estimated 1,300 pairs of red-throated diver breed in Britain, with the majority of pairs found in the north and west of Scotland (Musgrove *et al*., 2013; Balmer *et al*., 2013). The wintering population around Britain has been estimated at 17,000 individuals (O'Brien *et al*., 2008) and the 1% threshold for national importance is 170 birds (Musgrove *et al*., 2011). Several important areas for the species off the east coast of England have recently been identified; in particular, the outer Thames Estuary and the Greater Wash (O'Brien *et al*., 2008).

7.4.5.10 Red-throated diver is listed as a qualifying interest species in the non-breeding season for two SPAs and one potential SPA on the UK east coast: the Outer Thames Estuary SPA; Firth of Forth SPA; and Greater Wash pSPA. The Outer Thames Estuary SPA regularly supports wintering red-throated diver in numbers of European importance (6,466 individuals – wintering 1989–2006/07) (Natural England/JNCC, 2010), which is around 38% of the British wintering population.

7.4.5.11 The Greater Wash pSPA regularly supports 1,511 red-throated diver, or nearly 9% of the British wintering population, making this the second most important area for red-throated diver around the coast of the UK after the Outer Thames Estuary (Natural England, 2016). The highest densities of divers within the Greater Wash pSPA occur close inshore (up to 3.38 birds/km^2), particularly in the area outside The Wash SPA, north of the Humber Estuary and along the eastern part of North Norfolk Coast (Lawson *et al*, 2015).

7.4.5.12 Red-throated diver were recorded in two of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. A total of six birds were recorded during May 2016 translating to a peak population estimate of 66 birds. Although this population occurred during the breeding season defined for red-throated diver these birds are not considered to be breeding birds. There is considered to be no connectivity between Hornsea Three and red-throated diver breeding areas with the closest breeding areas to Hornsea Three in northern Scotland (Cramp & Perrins 1997 – 1994; Forrester *et al.,* 2007; Thaxter *et al.,* 2012; Wernham *et al.,* 2002). Birds recorded at Hornsea Three during the defined breeding season for red-throated diver are therefore considered to be non-breeding birds or birds on passage. In addition to the birds recorded in May 2016 a further two birds were recorded in April 2017, translating a to population estimate of 30 birds. These populations do not surpass the 1% regional threshold of the population of red-throated diver that occurs in the south-west North Sea during migration (133 individuals).

Fulmar

7.4.5.13 Fulmar is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). Fulmar is however currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015). The species is one of the most common seabirds in Britain, with an estimated breeding population of 499,081 pairs (Mitchell *et al.*, 2004). The largest breeding colonies are located off the north and west coasts of Scotland with birds often present at these colonies outside of the breeding season.

7.4.5.14 Between March and July, fulmars are distributed widely across the southern North Sea, although numbers are relatively low compared to further north along Scottish coasts, where the majority of British colonies occur (Stone *et al.*, 1995). From August to November, distribution extends southwards from the main breeding colonies. Through the rest of the winter this species is very widely distributed across the whole North Sea, although it is evident that the continental shelf edge is important for fulmar at most times of the year, with the closest area of high concentrations to Hornsea Three being at Dogger Bank (Stone *et al.*, 1995).

7.4.5.15 Historical survey data suggests that the Hornsea Three array area supports relatively low to moderate densities of fulmar (1.23-2.32 birds/km^2). The highest predicted densities in the North Sea in the summer (April to September) occur to the north-west of Hornsea Three off the Northumberland coast (see Figure 1.40 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report). From August to November, distribution extends southwards from the main breeding colonies (Stone *et al.,* 1995). Through the rest of the winter this species is very widely distributed across the whole North Sea, although it is evident that the continental shelf edge is important for fulmar at most times of the year, with the closest area of high concentrations (up to 5 birds/km^2) to Hornsea Three being at Dogger Bank (Stone *et al.,* 1995). Moderate densities (0.59 – 0.9 birds/km^2) of fulmar occur at Hornsea Three during winter months (October to March), although these densities are lower than those predicted in the summer. The highest predicted densities in the winter (up to 2.14 birds/km^2) again occur to the north-west of Hornsea Three approximately 40 km from the Yorkshire coast.

7.4.5.16 Hornsea Three lies within the mean maximum foraging range of fulmar (400 ± 245.8 km; Thaxter *et al.,* 2012) from four SPAs and one pSPA, Northumberland Marine SPA, Flamborough and Filey Coast pSPA, Forth Islands SPA, Farne Islands SPA and Coquet Island SPA. Fulmar is not a qualifying feature in its own right but is listed as a main component of the seabird assemblage at the Flamborough and Filey Coast pSPA and the Forth Islands SPA and is a non-listed assemblage feature at the Northumberland Marine SPA, Farne Islands SPA and Coquet Island SPA.

7.4.5.17 Fulmars were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. In the breeding season (April to August) a peak population of 1,554 birds occurred in August 2017. This population and those estimated in April, May and June of both 2016 and 2017 and July 2017 exceed the 1% threshold of the regional breeding population (117 individuals). However, none of these populations exceed the 1% threshold of the national breeding population.

7.4.5.18 In surveys undertaken in the post-breeding season (September to October), a peak population estimate of 1,347 birds occurred in September 2016. This population does not exceed the 1% threshold of the post-breeding BDMPS population for fulmar. Similarly, for surveys undertaken in the pre-breeding season (December to March), the peak population of 997 birds that occurred in December was also not of regional importance.

7.4.5.19 The non-breeding season for fulmar is defined as the month of November only. A population of 450 fulmars were estimated to be present within Hornsea Three offshore ornithology study area during the aerial survey undertaken during November 2017. This population does not exceed the 1% threshold of the regional BDMPS population for fulmar (5,687 individuals).

Gannet

7.4.5.20 Gannet is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). Gannet is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

7.4.5.21 Gannet has a widely dispersed population throughout the southern North Sea with an estimated flyway population of 892,000 individuals (Stienen *et al.*, 2007). Of this population, it is estimated that 40-60,000 birds pass through the southern North Sea en route to the Strait of Dover, with 10,000 birds remaining in the area through winter (Stienen *et al.*, 2007). From March to August gannets are present in low densities (up to 0.99 birds/km^2) in the southern North Sea with populations concentrated on the shelf edge or, in the breeding season, around the major colonies (Stone *et al.*, 1995). Historical survey data suggests that densities of the species are relatively low (<0.01-0.91 birds/km^2) at Hornsea Three during the summer (April to September) (see Figure 1.41 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report). However, the population of gannet at Bempton Cliffs is now much larger than throughout the majority of the period during which historical survey data were collected (JNCC, 2017c). In the winter (October to March), predicted densities of gannet at Hornsea Three are again relatively low (<0.01-0.92 birds/km^2) (see Figure 1.41 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report).

7.4.5.22 The UK breeding population of gannet has been estimated at 220,000 pairs (Musgrove *et al*., 2013). The species breeds at 26 large colonies around the UK, the nearest to the former Hornsea Zone being at Bempton Cliffs within FFC pSPA (Balmer *et al*., 2013). This colony was estimated at 7,859 nests in 2009 (JNCC, 2017c) and increased to an estimated 11,061 pairs in 2012 and 12,494 pairs in 2015. Breeding birds have been shown by satellite-tagging to range widely across the North Sea, at times as far as the Norwegian coast (Hamer *et al*., 2007). However, an analysis of tracking data by Wakefield *et al*. (2013) suggested that in the North Sea there was limited overlap between the foraging areas of gannets from the Bempton Cliffs breeding colony and the breeding colony at Bass Rock.

7.4.5.23 Gannet is listed as a qualifying interest species in the breeding season for four SPAs and two pSPAs on the UK east coast. These SPAs were designated for 54,495 pairs at time of designation, representing nearly 25% of the current national population of gannet (Wanless *et al*., 2005). Hornsea Three lies within the mean-maximum forging range of gannet (229.4 km) (Thaxter *et al*., 2012) from only the FFC pSPA although the Firth of Forth Islands SPA is within the estimated maximum foraging range of 590 km. However, Wakefield *et al*. (2013) indicates that the foraging areas of gannets from these two colonies shows little overlap.

7.4.5.24 Gannets were recorded in all of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. The peak population during the breeding season (April to August) was recorded in August 2017 when an estimated 2,207 birds occurred. This population and those recorded in April, May, June and July 2016 and July 2017 exceed the 1% threshold of the regional breeding population (250 individuals). However, none of these populations exceed the 1% threshold of the national breeding population (4,400 individuals).

7.4.5.25 In aerial surveys undertaken in the post-breeding season as defined for gannet (September to November) a peak population of 2,638 birds was recorded during October 2017. This population does not exceed the 1% threshold of the post-breeding BDMPS population for gannet (4,563 individuals). Similarly, during surveys undertaken in the pre-breeding season (December to March) the peak population of 1,099 birds that occurred in December was also not of regional importance (1% threshold of 2,484 individuals).

Puffin

7.4.5.26 Puffin is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act. The species is however currently red-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

7.4.5.27 Puffins are one of the most common seabird species in Britain, breeding in coastal colonies. Seabird 2000 recorded 579,500 pairs at breeding colonies around Britain (Mitchell *et al*., 2004).

7.4.5.28 During the breeding season puffin are aggregated around their colonies along the east coast and high densities are found in the Flamborough Head area. During post-breeding, however, the birds disperse towards the north-western North Sea before spreading out more widely throughout the winter months (Stone *et al*., 1995).

7.4.5.29 Between April and July, the Flamborough Head area supports densities of up to five birds/km^2 due to the high numbers of birds foraging in the area local to the breeding colony. This continues into the non-breeding season months of August to September as puffins are leaving the colony (Stone et al., 1995). Predicted densities of puffin in the summer (April to September) as derived from historical survey data suggest high densities (up to 5.58 birds/km^2) of the species occur in inshore areas along the eastern coast of England between the two main breeding colonies on this coast at Flamborough and the Farne Islands (see Figure 1.44 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report). Predicted densities in the summer at Hornsea Three are relatively low (0.00-0.24 birds/km^2). In the winter, predicted densities of puffin are relatively low at Hornsea Three (0.00-0.02 birds/km^2) with the highest predicted densities associated with the Dogger Bank area approximately 100 km to the north of Hornsea Three (up to 0.83 birds/km^2).

7.4.5.30 Puffin is listed as a qualifying interest species in the breeding season for eleven SPAs and two pSPAs on the UK east coast. The distance between Hornsea Three and the nearest designated site (FFC pSPA) is within the mean-maximum foraging range ± 1 standard deviation of puffin (105.4 ± 46 km) (Thaxter *et al*., 2012). Puffin is a non-listed assemblage feature at FFC pSPA. No other SPAs are within the mean-maximum or maximum foraging range (200 km; Thaxter *et al*., 2012) of puffin from Hornsea Three.

7.4.5.31 Puffins were recorded in twelve of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. Two seasons are defined for puffin, a breeding season from May to July and a non-breeding season from August to April. The peak population recorded in the breeding season occurred in May 2016 when a population of 352 birds was estimated. This surpasses the 1% threshold of regional importance for puffin (50 birds) with the population estimated in and May and July 2017 also surpassing the threshold for regional importance.

7.4.5.32 In surveys undertaken in the non-breeding season, puffins were recorded in seven surveys with an estimated peak population of 266 birds in April 2016. This population does not exceed the 1% threshold of the regional non-breeding BDMPS population for puffin (2,320 individuals).

Razorbill

7.4.5.33 Razorbill is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). The species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

7.4.5.34 Seabird 2000 recorded 164,557 individuals at breeding colonies around Britain (Mitchell *et al*., 2004). Razorbill is listed as a qualifying interest species in the breeding season for eleven SPAs and one pSPA on the UK east coast. These SPAs are designated for 41,821 pairs representing approximately 38% of the most UK population as counted during Seabird 2000 (Mitchell *et al*. 2004). The closest SPA to Hornsea Three is at FFC pSPA which held an estimated 10,570 pairs in 2008-12. However, Hornsea Three is outside of the mean-maximum (48.5 km) and maximum (95 km) foraging ranges of razorbill as reported by Thaxter *et al*. (2012).

7.4.5.35 High densities of razorbills (up to 5 birds/km^2) have been recorded in the north-western North Sea with lower densities (generally up to 1.99 birds/km^2) recorded overwintering in the southern North Sea (Stone *et al*., 1995). With a flyway population of some 482,000 birds in the southern North Sea, between 1.3 and 2.0% of the biogeographic population are estimated to move through this area (Stienen *et al*., 2007).

7.4.5.36 From April to August during the incubating and chick-rearing season, razorbills are generally confined to coastal areas from Flamborough Head northwards along the east coast. Predicted densities of razorbill during the summer (April to September), derived from historical surveys, are highest (3.62-5.55 birds/km2) in inshore areas along the eastern coast of England between Yorkshire and Northumberland, extending into offshore areas from the breeding colony at Flamborough, although not as far as Hornsea Three (see Figure 1.45 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report). From August to September densities of more than five birds/km2 can be found in the Flamborough area, as young birds disperse from the colony with their parents. Very few birds were reported in the vicinity of Hornsea Three by Stone et al. (1995). Between October and March there are low to moderate densities (0.05-0.18 birds/km^2) in the southern North Sea with low densities along the east coast of up to one bird/km^2 (Stone et al., 1995).

7.4.5.37 Razorbills were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area with the exception of the August 2016 survey. In surveys undertaken during the breeding season defined for razorbill (April to July) a peak population of 736 birds was estimated in April 2017. This population estimate does not exceed the 1% threshold for national importance (2,600 individuals).

7.4.5.38 In the post-breeding season (August to October), the peak population of razorbill was estimated in October (4,022 birds). This population does not surpass the 1% threshold of regional importance (5,912 individuals). Similarly in the pre-breeding season (January to March), the peak population of 2, 972 birds estimated in March does not exceed the 1% threshold of regional importance (5,912 individuals).

7.4.5.39 The largest populations of razorbill estimated from aerial survey data were in the non-breeding season (November to December). In the three surveys undertaken in this season populations of 4,976 (November 2016), 3,648 (December) and 4,352 (November 2017) birds were estimated. These populations all exceed the 1% threshold of regional importance (2,186 individuals) but do not exceed the 1% threshold of the national non-breeding population of razorbill (5,600 individuals).

Guillemot

7.4.5.40 Guillemot is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). The species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al*., 2015).

7.4.5.41 The southern North Sea is important for guillemots throughout the year with high densities in all months. With a total flyway population of 1,990,000 birds, 1.5 to 3.0% of the biogeographic population resides in or flies over the southern North Sea (Stienen *et al*., 2007).

7.4.5.42 Seabird 2000 recorded 1,322,830 individuals at breeding colonies in Britain (Mitchell *et al*., 2004). Guillemot is listed as a qualifying interest species in the breeding season for nineteen SPAs and one pSPA on the UK east coast. These SPAs are designated for 487,801 breeding pairs representing approximately 37% of the UK breeding population as recorded during Seabird 2000 (Mitchell *et al*. 2004). The closest SPAs to Hornsea Three are at the Farne Islands and Bempton Cliffs (including Flamborough Head).

7.4.5.43 From March to June, guillemot densities are high in the southern North Sea, notably in the Dogger Bank area. These densities of between two and five birds/km^2 reflect both high levels of pre-breeding activity (when birds from further afield are foraging more widely) and also that local colonies are showing more concentrated foraging activity at the start of the breeding season. This is evident in the Flamborough Head area (Stone et al., 1995). During July and August, chicks and adults depart the colonies resulting in high densities (more than five birds/km^2) being found in both these months around Flamborough Head and Dogger Bank. These high densities remain throughout the winter months from October to February (Stone et al., 1995).

7.4.5.44 A similar distribution is evident from historical survey data with the highest densities of guillemot (up to 22.68 birds/km^2) in the summer (April to September) associated with inshore areas between the Northumberland coast and Flamborough with densities extending offshore from the Flamborough breeding colony in a north-easterly direction (see Figure 1.46 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report). In the winter (October to March) densities are lower (up to 16.3 birds/km^2) throughout the North Sea with the main concentration of guillemot associated with the Dogger Bank area.

7.4.5.45 Guillemot were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. During surveys undertaken in the breeding season defined for guillemot (March to July), a peak population of 19,360 birds was estimated in June. The population estimated to be present in the Hornsea Three offshore ornithology study area in this month did not surpass the 1% threshold of national importance (19,000 individuals).

7.4.5.46 In the non-breeding season a peak population of 26,561 birds was estimated from aerial survey data collected in November 2017. This population and those estimated in August, September November and December 2016 and August, September and October 2017 exceed the 1% threshold of regional importance (16,173 individuals) but are not considered to be of national significance (27,565 individuals).

7.4.5.47 The closest colony to Hornsea Three is FFC pSPA which supported 41,607 pairs in 2008-12. The distance between Hornsea Three and FFC pSPA is approximately 149 km, further than the maximum foraging range of guillemot (135 km; Thaxter *et al*., 2012).

Sandwich tern

7.4.5.48 Sandwich tern is listed on Annex I of the EU Birds Directive (2009/147/EEC), and the species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al*., 2015).

7.4.5.49 Sandwich terns are summer visitors to Britain, breeding in coastal colonies with Seabird 2000 recording 10,536 pairs (Mitchell *et al*., 2004). The closest colonies to Hornsea Three are on the north Norfolk Coast at Blakeney Point and Scolt Head which form part of the North Norfolk Coast SPA. After the breeding season, Sandwich terns migrate south to the west coast of Africa, returning the following spring (Wernham *et al.,* 2002). Sandwich terns feed on a variety of small, surface-feeding fish including sandeels but also cephalopods and crustaceans that they catch by plunge-diving (Brown and Grice, 2005).

7.4.5.50 Predicted densities of Sandwich tern in the summer (April to September) shown in Figure 1.45 (WWT Consulting and MacArthur Green, 2013), indicate that the species is abundant off the north Norfolk coast with relatively low densities present at Hornsea Three and in surrounding sea areas.

7.4.5.51 Sandwich tern is listed as a qualifying interest species in the breeding season for six SPAs and four pSPAs on the UK east coast (Table 1.28). These SPAs held 8,943 pairs at the time of designation. The distance between all these sites and Hornsea Three is beyond the maximum foraging range of Sandwich terns (54 km) (Thaxter *et al*., 2012).

7.4.5.52 Sandwich terns were recorded in two of the aerial surveys conducted across Hornsea Three plus a 4 km buffer. A total of three birds were recorded during the August 2017 survey with four recorded in the September 2017 survey. These counts translate to population estimates (see Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report for methodology) of 35 and 162 birds respectively (Table 1.29, Figure 1.21). These birds are migratory individuals, with these population estimates not surpassing the 1% threshold for regional importance (1% threshold = 381 individuals).

Kittiwake

7.4.5.53 Kittiwake is currently red-listed on the UK Birds of Conservation Concern list (Eaton et al., 2015). The species is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended).

7.4.5.54 Kittiwake is one of the commonest seabirds in the UK, breeding in large colonies on coastal cliff habitat. Seabird 2000 recorded 366,835 pairs in the UK, with the largest numbers on the east coast (Mitchell *et al*., 2004). Kittiwake is listed as a qualifying interest species in the breeding season for 21 SPAs and 2 pSPAs on the UK east coast. These SPAs are designated for 256,160 breeding pairs representing nearly 70% of the national breeding population as recorded during Seabird 2000 (Mitchell *et al*., 2004). The nearest SPA to Hornsea Three is at Flamborough Head and Bempton Cliffs (Filey and Flamborough pSPA). The southern North Sea holds around 5% of the biogeographic population of kittiwake, with numbers in excess of 30,000 individuals being found here at some point during the year (Stienen *et al*., 2007). Between April and July, kittiwakes are dispersed widely around the coast of Britain, with relatively low densities throughout the southern North Sea, compared to more northerly areas, where the main breeding colonies are located (Stone *et al*., 1995). In eastern England, particularly south of Flamborough Head, kittiwake colonies are few, due to the lack of suitable cliff-face breeding habitats.

7.4.5.55 Between April and July, kittiwakes are dispersed widely around the coast of Britain, with only moderate densities (generally up to 4.99 birds/km^2) throughout the southern North Sea, compared to more northerly areas, where the main breeding colonies are located (Stone et al., 1995). In eastern England, particularly south of Flamborough Head, there are few kittiwake colonies, due to the lack of suitable cliff-face breeding habitats. However, predicted densities, derived from historical survey data, are high (up to 19.8 birds/km^2) in offshore areas to the east of the colony at Flamborough Head, however such high densities do not extend as far as Hornsea Three (see Figure 1.50 in Environmental Statement volume 5, annex 5.1: Baseline Characterisation Report).

7.4.5.56 From August to October, kittiwakes begin to disperse across the North Sea, although the predominant concentrations in this distribution still reflect the location of breeding colonies. From November to March, birds are dispersed over much larger areas of the North Sea, and in the southern parts, numbers peak during this period. This reflects the kittiwakes preference for pelagic habitats in winter. The highest predicted densities (up to 11.9 birds/km^2) in the winter (October to March) occur offshore of the Yorkshire and Lincolnshire coast and also in the Dogger Bank area. At Hornsea Three during this period, predicted densities are relatively low.

7.4.5.57 Kittiwakes were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. Population estimates derived from aerial survey data during all breeding months surpass the 1% threshold for regional importance. The population estimates calculated for April (8,451 birds) and July 2016 (12,551 birds) also exceed the 1% threshold for national importance. A marked reduction in the abundance of kittiwake at Hornsea Three array area between April 2016 (8,451 birds) and May 2016 (4,842 birds), and particularly thereafter in June 2016 (1,152 birds) coincides with chick provisioning by breeding adults when this 'central place forager' is most constrained by distance from their nesting site (see 5.6.6.18). This trend also existed in the chick-rearing period of 2017 (between April and June) although the population in May 2017 did increase when compared to the previous month. Combined with the preliminary results of the FAME project, the evidence suggests that the kittiwake population in Hornsea Three during June and to a lesser extent May, comprises non-breeders, with the likely arrival of further immatures into the area explaining the 10-fold increase in abundance in July. Further discussion regarding the trends in kittiwake abundance observed at Hornsea Three is provided in Annex 3: Phenology, connectivity and apportioning for features of the FFC pSPA.

7.4.5.58 Populations estimated during the post-breeding season (August to December) did not surpass the 1% threshold of the post-breeding regional BDMPS population for kittiwake (8,299 individuals) The peak population during the post-breeding season was in December with 3,591 birds estimated to be present. Populations estimated during the surveys undertaken in the pre-breeding season (January to March) also did not surpass the 1% threshold for regional importance (6,278 individuals) with the peak population occurring in the March survey (2,812 birds).

7.4.5.59 Filey and Flamborough pSPA is the closest SPA/pSPA to Hornsea Three. However, Hornsea Three is outside of the maximum foraging range of 120 km of kittiwake from the pSPA as reported by Thaxter *et al*. (2012). Preliminary results from the FAME project which has tracked breeding kittiwake from the FFC pSPA colony does however suggest that there may be connectivity between the FFC pSPA and Hornsea Three.

7.4.6 Data limitations

7.4.6.1 The baseline characterisation of Hornsea Three and resulting assessments include data from twenty months of aerial surveys (April 2016 to November 2017). Two years of data are available for April to November covering all or the majority of the breeding season for all VORs. Only one year of data will be available for December to March. These months form part of non-breeding seasons for all species included in this assessment (with the exception of guillemot for which March is a breeding season month), with this period generally representing a period of reduced abundance for the majority of species. As such, the magnitude of impacts is likely to be lower during this period and potential impacts should not disproportionally affect local breeding populations based on large BDMPS population sizes and low apportioning values (see Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). Despite this a process has been undertaken to reduce the uncertainty associated with having only one year of data for certain months. This process is described in the document titled 'A method for assessing priority of seabird density data for use in EIA at Hornsea 3. Addendum 1.' and incorporated into the assessments for all relevant species.

7.4.6.2 As detailed in Section 7.3.3, the flight height data collected as part of the digital aerial survey programme was not found to be adequate. To inform collision risk modelling Option 1 of Band (2012) incorporates site-specific flight height data (from the boat-based survey programmes supporting the applications for the Hornsea Project One and Hornsea Project Two offshore wind farm), while collision risk estimates calculated using Options 2 and 3 of Band (2012) make use of aggregated flight height data contained in Johnston *et al*. (2014).

7.4.7 Apportioning and seasonal BDMPS

7.4.7.1 The birds present at Hornsea Three may vary in their origin depending on the biological season. The area within which these birds occur can be defined as the Biologically Defined Minimum Population Scale (BDMPS). For example, during the breeding season, birds are less likely to travel as far as they are provisioning chicks and, as such, tend to travel within their 'foraging range'.

7.4.7.2 Outside of the breeding season, migratory birds are more likely to be present within a defined BDMPS, and as such this may introduce birds from a much wider area and therefore range of populations. This has relevance to the overall apportioning of impacts as it defines the relevant populations within a BDMPS against which assessment should be undertaken, both for individual projects (e.g. Hornsea Three) and in-combination with other offshore wind farms.

7.4.7.3 The apportioning values used within this assessment have been calculated following the methodologies applied and accepted as part of the application and examination of Hornsea Project Two updated where required for Hornsea Three. The approaches applied use information from Furness (2015) to explore the appropriate definition of appropriate seasons and the BDMPS populations within these seasons for the relevant species (see Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA).

7.5 Assessment of Adverse Effects on Integrity – Alone

7.5.1 Greater Wash pSPA

Site description

7.5.1.1 Natural England is responsible for recommending SPAs in English waters out to 12 nautical miles to the Department for Environment, Food and Rural Affairs (Defra) for classification. As part of wider work to identify potential SPAs (pSPAs) in UK waters, Natural England has compiled information in relation to the creation of a new SPA called the 'Greater Wash SPA' off the eastern coast of England. This new marine SPA would be located between Bridlington Bay, East Yorkshire and the area just north of Great Yarmouth on the Norfolk coast. The SPA would have a landward boundary at Mean High Water and an offshore extent of around 30 km at its furthest point.

7.5.1.2 The identification of qualifying features for the pSPA was supported by Wilson *et al.* (2014) and Lawson *et al.* (2015). Six features have been identified (Natural England and JNCC, 2016) that will form part of the Greater Wash SPA designation. These bird features fall into three categories:

- Annex I tern species that use relatively restricted areas around their breeding colonies for foraging;
- Non-breeding Annex I species; and
- Non-breeding regularly occurring migratory species.

7.5.1.3 Annex I tern species include Sandwich tern, common tern and little tern. The non-breeding Annex I species are red-throated diver and little gull and the regularly occurring migratory species are common scoter.

7.5.1.4 A number of SPAs that are designated for breeding tern species (common tern, Sandwich tern and little tern) are located adjacent or in close proximity to the Greater Wash (Humber Estuary, Gibraltar Point, The Wash, North Norfolk Coast, Great Yarmouth North Denes and Breydon Water). The waters adjacent to these colonies are utilised by terns for a range of activities, including foraging. All terns are central place foragers leaving and returning to the breeding colony (the central place) on every foraging trip. However, the foraging areas upon which these terns rely are not currently afforded the same level of protection as breeding colonies. As such, work to identify potential marine SPAs undertaken by Natural England has included consideration of foraging areas used by tern species breeding in existing SPAs.

7.5.1.5 The inclusion of foraging terns as a qualifying feature of the Greater Wash pSPA was informed by Wilson *et al.* (2014) which investigated the usage of offshore areas by foraging common and Sandwich terns from a number of breeding colonies around the coast of the UK. Of relevance to the Greater Wash, Wilson *et al.* (2014) modelled the likely foraging activity of common terns and Sandwich terns from colonies at the North Norfolk Coast SPA (amongst other SPAs as detailed above). Using these data the foraging areas of common tern and Sandwich tern from these colonies were identified and incorporated into the boundary for the Greater Wash pSPA.

7.5.1.6 In addition to common and Sandwich terns, the foraging areas of little tern from colonies adjacent to the Greater Wash were identified (Parsons *et al.*, 2015) and also incorporated into the pSPA boundary. Of relevance to the Greater Wash, Parsons *et al.* (2015) identified the maximum seaward extent and maximum alongshore lengths for foraging of little tern at colonies on the North Norfolk Coast SPA, Gibraltar Point SPA and Great Yarmouth North Denes SPA. Using these data, the foraging areas of little tern were identified and incorporated into the boundary for the Greater Wash pSPA.

7.5.1.7 The distribution of red-throated diver, common scoter and little gull in the Greater Wash pSPA was identified based on aerial survey data collected in the Greater Wash during the non-breeding season (October to March) from 2002/03 to 2007/08 (Lawson *et al.*, 2015).

7.5.1.8 Red-throated divers were present in all of the surveys undertaken across the Greater Wash between 2002 and 2008. Red-throated divers were distributed throughout the Greater Wash with the highest densities fairly mobile within and between years. The mean peak population estimate was taken over three winter seasons (2002/03, 2004/05, 2005/06), and the SPA citation population was 1,511 birds making the Greater Wash the second most important area for the species in the UK. This population far exceeds the GB threshold for the species (170 individuals) (Lawson *et al.*, 2015, Natural England and JNCC, 2016).

7.5.1.9 A mean-peak population of 1,303 individual little gulls was estimated to be present in the Greater Wash during the non-breeding season making this the largest population in any inshore area around the UK. The highest densities of little gull were concentrated to the north-east of the Inner Wash. Populations of little gull exhibited a high degree of temporal variability with low populations recorded in some surveys (Lawson *et al.*, 2015).

7.5.1.10 Populations of common scoter showed a high degree of temporal variability varying from flocks of a few individuals to flocks over 1,000 individuals. Lawson *et al.* (2015) estimated that a mean population of 3,463 common scoters was present in the Greater Wash area. This population is lower than the 1% threshold of the biogeographic population of the species and therefore does not meet the Stage 1.2 threshold of the UK SPA selection guidelines. However, it has been proposed that common scoter be considered for inclusion within the SPA designation based on the consistent presence of dense flocks of this species off the North Norfolk coast which make this area the fifth most important for the species in the UK (Natural England and JNCC, 2016).

Features screened into assessment

7.5.1.11 Table 7.6 provides a summary of the outcomes of screening with respect to the Greater Wash pSPA. The features screened into the assessment are red-throated diver, common scoter and Sandwich tern.

Table 7.6: Results of screening with respect to the interest features of the Greater Wash pSPA

Feature	Project Phase	Potential Impact	Likely Significant Effect
Red-throated diver	Construction / decommissioning	Disturbance	Potential for LSE
		Changes to prey availability	No
	Operation	Displacement	Potential for LSE
Common scoter	Construction / decommissioning	Disturbance	Potential for LSE
		Changes to prey availability	No
	Operation	Displacement	Potential for LSE
Sandwich tern	Construction / decommissioning	Disturbance	Potential for LSE
		Changes to prey availability	Potential for LSE
	Operation	Displacement	No
Common tern	All	All	No
Little tern	All	All	No
Little gull	All	All	No

Common scoter

<u>Construction/decommissioning</u>

Disturbance

7.5.1.12 Common scoter have the potential to be disturbed from the export cable corridor from Hornsea Three. No common scoter were recorded in aerial surveys undertaken across Hornsea Three plus a 4 km buffer and as such, there is considered to be no pathway for effect from the Hornsea Three array area. The absence of common scoter in offshore areas is also evident in the results presented in Stone *et al.* (1995) with high densities of common scoter in inshore areas only.

7.5.1.13 Lawson *et al.* (2015) estimated that the number of common scoter present in the Greater Wash only exceeded 1% of the biogeographic population (5,500 individuals) in one winter season. The mean-peak population of common scoter in the Greater Wash is 3,463 individuals (Natural England and JNCC, 2016) and this is therefore used as the population metric against which impacts are assessed.

7.5.1.14 In order to calculate the magnitude of impact associated with construction activities related to export cable installation, survey data incorporated into Lawson *et al.* (2015) has been analysed in order to calculate the population of common scoter that may be affected. These surveys were undertaken during the wintering period (October to March) between 2002 and 2008 and covered the Greater Wash Area of Search, an area stretching from Bridlington Bay, East Yorkshire in the north and Great Yarmouth, Norfolk in the south, extending over 50 km offshore in some places Figure 7.2. The main concentrations of common scoter in the Greater Wash pSPA occur along the North Norfolk Coast and into The Wash, with densities of up to 56.6 birds/km^2 occurring in these areas. No birds were present along the export cable route. These densities have been calculated from the data on which it Figure 7.2 is based.

7.5.1.15 The effects associated with export cable installation are expected to be highly localised as cable laying vessels are slow moving during the installation of cables. Furthermore, cable laying activity will be intermittent and therefore any displacement will be temporary and short term in nature. The level of noise associated with offshore cable installation activity is low when compared to activities such as piling with the presence of vessels the main cause of disturbance. The area of habitat disturbed due to vessel movements is considered to be very small in the context of the distribution of common scoter (i.e. limited to the immediate vicinity of where works are being carried out) within the Greater Wash. This also holds true when including the vessel activities and construction activities (e.g. piling) associated with the potential HVAC booster located along the cable route. The cable route does not pass through areas that contain notable densities of common scoter with no birds present in the export cable route as derived from interrogating the underlying data supporting the density map presented in Figure 7.2.

7.5.1.16 Lawson *et al*. (2015) demonstrated that the distribution of common scoter in the Greater Wash Area of Search is limited and consistently restricted to specific areas. The Hornsea Three export cable route runs through the Greater Wash making landfall near Weybourne on the North Norfolk coast, at least 35 km east of the highest densities of common scoter which are located in the mouth of The Wash. It should also be noted that the export cable route runs through an area of high vessel activity associated with vessel movements adjacent to the north-east coast of Norfolk (Figure 7.3). Shipping statistics for ports along the east coast of England between Berwick and Lowestoft indicate that in 2015 there were a total of 23,968 vessel arrivals into these ports, in addition there were many vessels moving through the Greater Wash Area of Search travelling towards ports in Scotland.

7.5.1.17 It should be noted that installation of export cables will occur over a maximum duration of three years. The export cables could be installed in up to two phases with a gap of three years between phases. Therefore the maximum duration over which export cables could be installed is eight years (Table 4.3). A worst-case of displacement is considered to be limited to the area around construction activities within the Hornsea Three offshore cable corridor that will be transitory in nature. Numbers affected will depend on the overlap of such activity with food resources at any particular time. It is however expected that considering the species distribution in the Greater Wash, no aggregations would be exposed to disturbance. It is considered that any disturbance would not affect foraging resources for common scoter and that there would therefore be no detectable consequences of the impact.

Conclusion

7.5.1.18 Effects associated with the installation of the export cable will be localised with an extremely low level of interaction between the export cable route and areas of supporting high densities of common scoter it is assessed that there is no indication of an adverse effect on the integrity of the common scoter population of the Greater Wash pSPA as a result of disturbance / displacement due to construction and decommissioning activities.

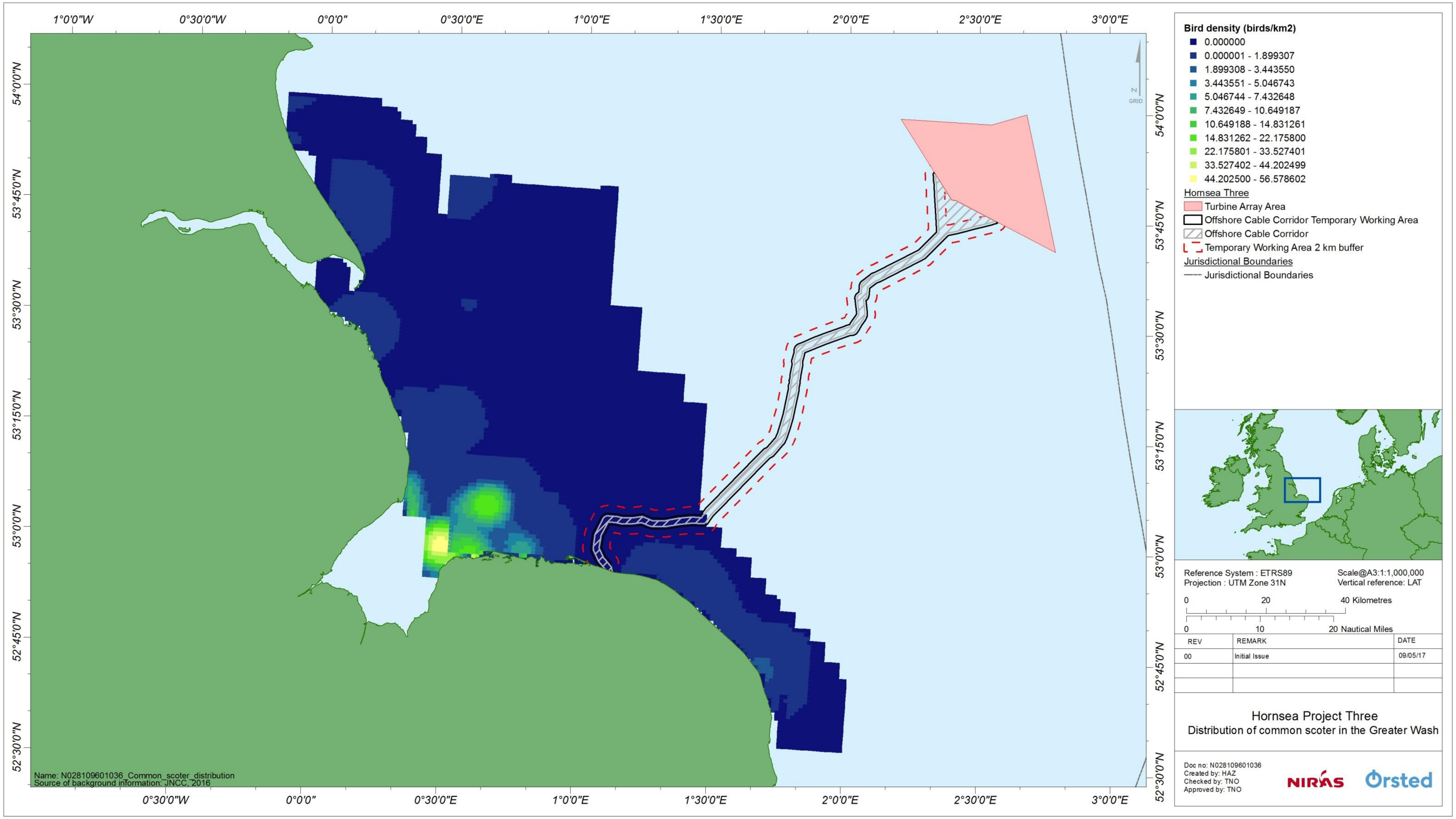


Figure 7.2: Distribution of common scoter in the Greater Wash (2002 – 2008; Lawson *et al.*, 2015).

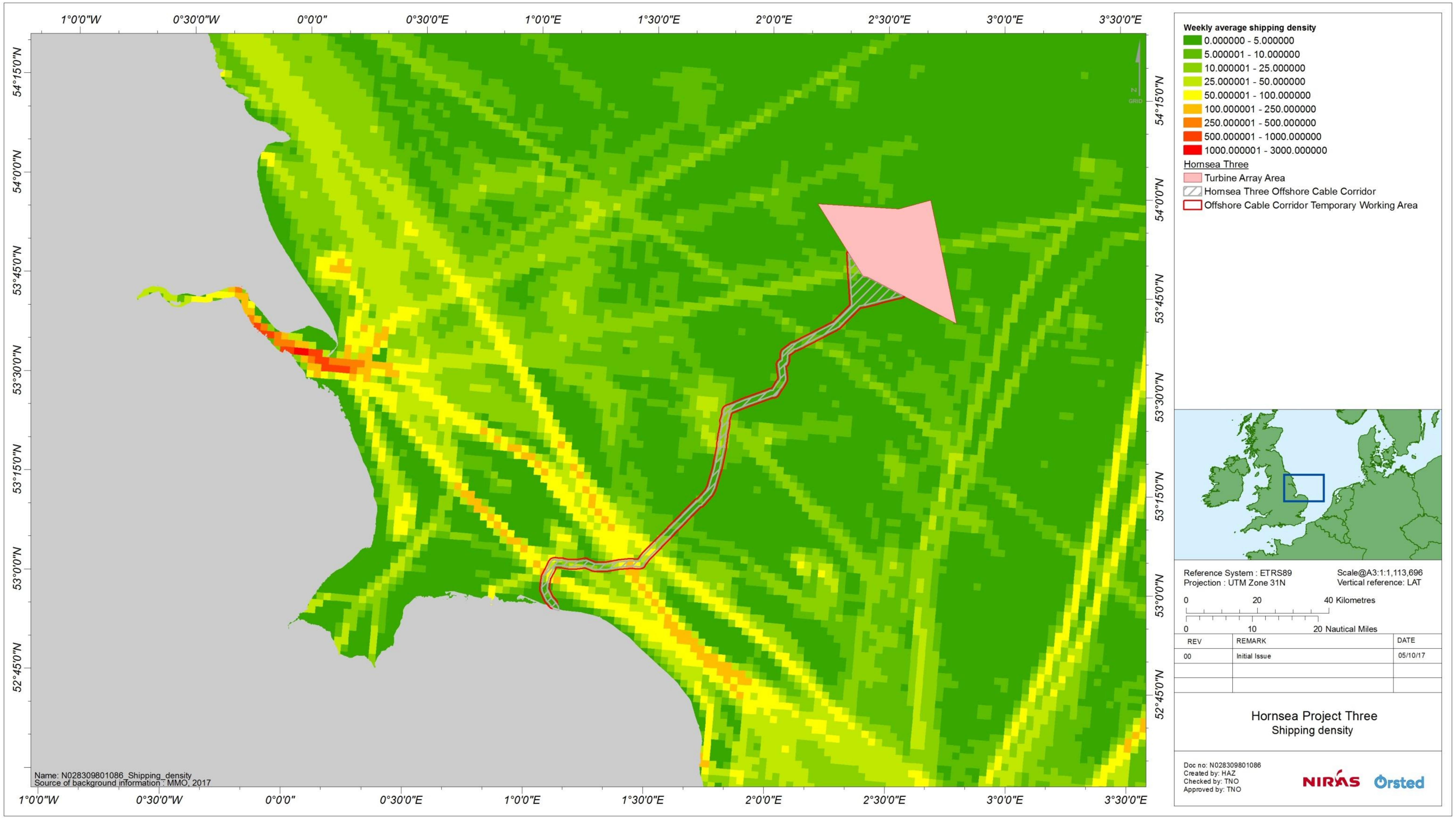


Figure 7.3: East coast weekly average vessel density 2015 (Source: MMO, 2017).

Operation/maintenance

Displacement

7.5.1.19 During the operation and maintenance phase of Hornsea Three, disturbance may occur as a result of vessel traffic associated with operation and maintenance activities at the array area. Common scoter is considered to have a high sensitivity to disturbance from vessels (Wade *et al.,* 2016).

7.5.1.20 The mean density surface map in Lawson *et al.* (2015) indicates that the area of the Greater Wash pSPA through which vessels will likely transit does not contain notable densities of common scoter. The effects of displacement on common scoter in the operational phase are considered highly likely to be at a lower level of magnitude to that described during the construction phase. Therefore it is considered extremely unlikely that maintenance activities at the Hornsea Three export cable route will result in any increase in disturbance effects on common scoter when compared to the level of disturbance already considered to be part of the baseline environment.

Conclusion

7.5.1.21 It is assessed that there is no indication of an adverse effect on the integrity of the common scoter population of the Greater Wash pSPA as a result of disturbance / displacement due to operation and maintenance activities.

Red-throated diver

Construction/decommissioning

Disturbance

7.5.1.22 Red-throated diver have the potential to be disturbed from the export cable corridor from Hornsea Three. There is no pathway for effect from the Hornsea Three array area of the Project.

7.5.1.23 The effects associated with export cable installation are expected to be highly localised as cable laying vessels are slow moving during the installation of cables. Furthermore, cable laying activity will be intermittent and therefore any displacement will be temporary and short term in nature. The level of noise associated with offshore cable installation activity is low when compared to activities such as piling with the presence of vessels the main cause of disturbance.

7.5.1.24 The main concentrations of red-throated diver in the Greater Wash are located off the north Norfolk coast and the Lincolnshire coast, around Gibraltar Point with densities of up to 3.38 birds/km^2 occurring in these areas (Figure 7.4). The Hornsea Three cable route runs through an area of relatively low densities, when compared to densities elsewhere in the Greater Wash with densities of up to 0.46 birds/km^2 possible along the cable route (Figure 7.4).

7.5.1.25 The maximum area from which red-throated divers could be disturbed due to construction activities associated with the Hornsea Three export cable route is defined as a 2 km buffer around each of the vessels directly involved in the installation of the export cable. This equates to an area of 113.1 km^2 (2 km buffer around nine vessels) which is considered to be precautionary as each vessel will not be located 2 km or more from other vessels and disturbance areas are expected to overlap.

7.5.1.26 In order to determine the potential impact on red-throated diver as a result of construction activities along the Hornsea Three offshore cable corridor, an estimate of the likely mean-peak population present is required (as recommended by JNCC *et al.,* 2017). The mean density surface presented in Figure 7.4 represents the average densities that would occur in each 1 km x 1 km square within the Greater Wash and if these values were to be used it could therefore be suggested that these would represent an under-estimate of the likely impact. In order to calculate a mean-peak population, the individual survey density surfaces that were used to calculate the mean density surface presented in Figure 7.4 were analysed to provide an average density for the Hornsea Three offshore cable corridor (represented by the temporary working area plus a 2 km buffer) for each individual survey. This was achieved by extracting and averaging all data that falls within the Hornsea Three offshore export cable corridor temporary working area plus a 2 km buffer. Using data from each individual survey, the peak densities in each season were then identified and then averaged to provide a mean-peak density.

7.5.1.27 The mean-peak density of red-throated diver within the export cable route plus a 2 km buffer as calculated from individual survey density surfaces in Figure 7.4 is 0.19 birds/km^2. If it is assumed that 100% of birds are within the area in which construction activities will occur (113.1 km^2), then using a bird density of 0.19 birds/km^2 it is predicted that 21 birds would be displaced during the installation of the export cable. As the presence of vessels in an area is temporary it is assumed that birds will soon return to the area from which they were displaced therefore reducing the temporal extent of the impact.

7.5.1.28 It should be noted that installation of export cables will occur over a maximum duration of three years. The export cables could be installed in up to two phases with a gap of three years between phases. Therefore the maximum duration over which export cables could be installed is eight years (Table 4.3). A worst-case of displacement is considered to be limited to the area around construction activities within the Hornsea Three offshore cable corridor that will be transitory in nature. Numbers affected will depend on the overlap of such activity with food resources at any particular time.

7.5.1.29 Following JNCC *et al.* (2017) interim guidance, a range of mortality rates have been applied to the displaced population of birds (Table 7.7). These results are expressed as a proportion (%) of the pSPA population for red-throated diver (1,511 individuals) and as a percentage change in baseline mortality.

Table 7.7: Displacement mortality of the Greater Wash pSPA feature red-throated diver from the Hornsea Three export cable route.

Magnitude of impact	Mortality rate (%)			
	1	2	5	10
Displacement mortality (no. of birds)	0.21	0.43	1.06	2.13
% of pSPA population	0.00	0.00	0.01	0.02
% increase in baseline mortality	0.01	0.03	0.07	0.13

7.5.1.30 There is no evidence currently available that displacement by vessels will directly result in the mortality of individual birds. Mortality as a consequence of displacement is more likely to occur as a result of increased densities outside of the impacted area, which may lead to increased competition for resources. Displacement of birds from low density areas (e.g. the area associated with the cable route), which are likely to be of lower habitat quality is less likely to result in mortality than would be the case in areas of high density and hence higher habitat quality. It being assumed that there are more opportunities for birds in lower quality habitats to relocate to habitats of similar quality. As such, the use of a 1% mortality rate is considered appropriate for this assessment.

7.5.1.31 Applying a 1% mortality rate results in a predicted mortality of less than one individual bird (Table 7.7). The magnitude of this impact is considered to be insignificant as it represents 0.01% of the Greater Wash pSPA population of red-throated diver and a very slight increase of 0.08% in the baseline mortality of that population.

Conclusion

7.5.1.32 On the basis of the information provided above in relation the limited temporal span and localised effect installation of the export cable, combined with the relatively low densities of red-throated diver along the cable route it is assessed that there is no indication, of an adverse effect on the integrity of the red-throated diver population of the Greater Wash pSPA as a result of disturbance caused by construction and decommissioning activities.

Operation/maintenance

Displacement

7.5.1.33 During the operation and maintenance phase of Hornsea Three, disturbance may occur as a result of vessel traffic associated with operation and maintenance activities at the array area leading to displacement. Red-throated diver is considered to have a high sensitivity to disturbance from vessels (Wade *et al.*, 2016).

7.5.1.34 The mean density surface map in Lawson *et al.* (2015) indicates that the area of the Greater Wash pSPA through which vessels will likely transit does not contain notable densities of red-throated diver. The effects of displacement on red-throated diver in the operational phase are likely to be at a significantly lower level of magnitude to that described during the construction phase as the level of activity associated with the export cable is significantly reduced. It is considered extremely unlikely that maintenance activities at the Hornsea Three export cable route will result in any increase in disturbance effects on red-throated diver when compared to the level of disturbance already considered to be part of the baseline environment.

Conclusion

7.5.1.35 It is assessed that there is no indication of an adverse effect on the integrity of the red-throated diver population of the Greater Wash pSPA as a result of disturbance / displacement due to operation and maintenance activities.

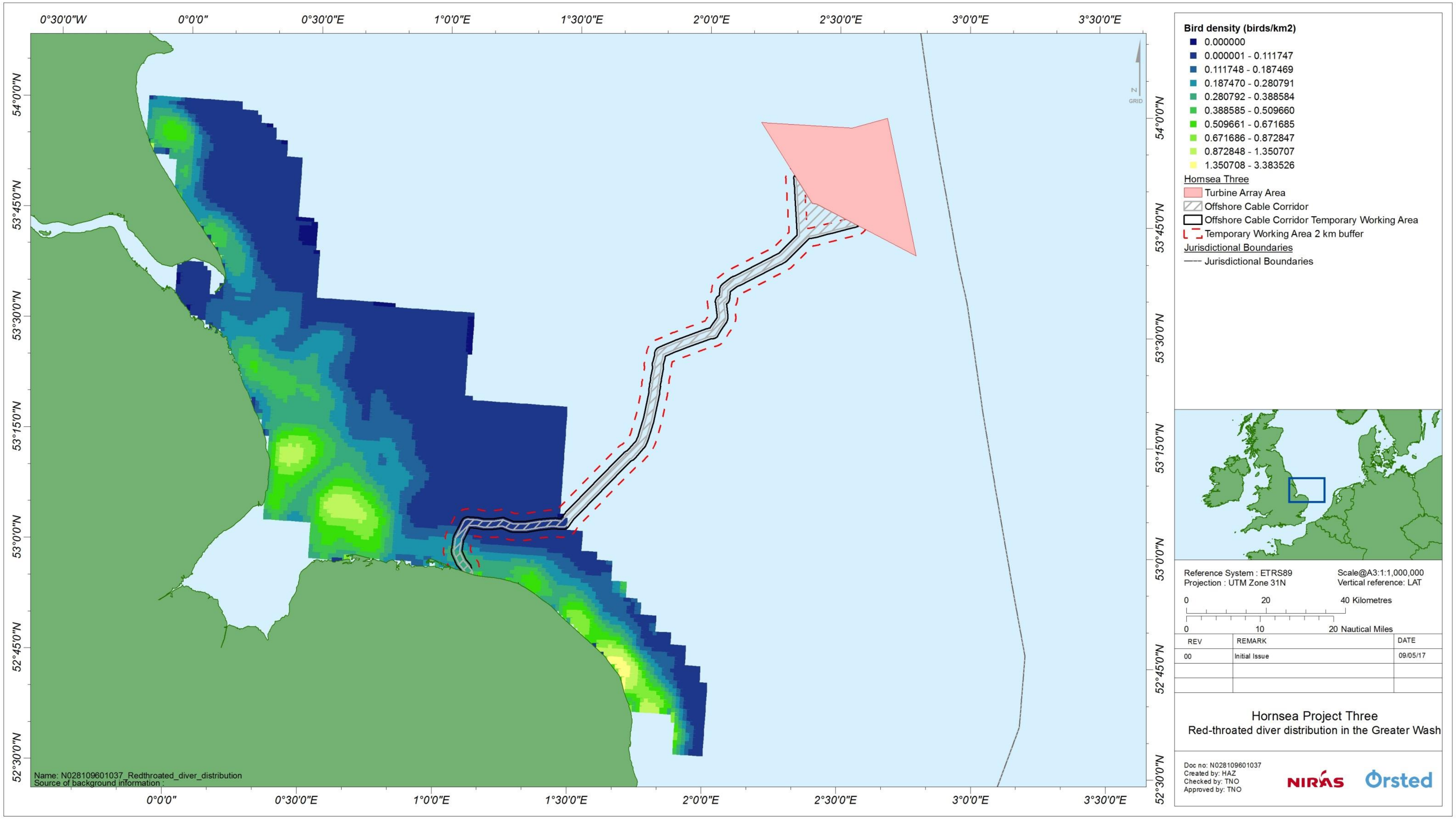


Figure 7.4: Red-throated diver distribution in the Greater Wash (2002-2008); Lawson *et al.*, 2015).

Sandwich tern

Construction/decommissioning

Disturbance

7.5.1.36 As noted in in the assessment presented above for common scoter, the nature of cable laying activities (highly localised, slow moving vessel, low noise levels and limited spatial extent of impact) will also reduce the likelihood of impacts on Sandwich tern. It is considered that the extent of any impact due to construction activities will extend no further than the close proximity around disturbance sources associated with the Hornsea Three export cable. Therefore, Sandwich tern is likely to be largely unaffected by disturbance.

7.5.1.37 The predicted usage of the Hornsea Three export cable route by Sandwich terns from the breeding colony at Blakeney Point is low with areas of higher usage located much closer to the colony (Figure 7.5). As such, it is considered that even if disturbance were to occur, it would affect a limited number of birds in an area that is of limited importance for foraging when compared to other areas. The majority of the foraging areas utilised by Sandwich terns from Blakeney Point, including those of highest utilisation, as identified by Wilson *et al*. (2014) are unaffected by disturbance from activities associated with the Hornsea Three export cable.

7.5.1.38 Sandwich tern is considered to be a species with a low sensitivity to vessel and helicopter disturbance (Wade *et al*., 2016) with the species seemingly tolerant of human activities at sea. For example, tracking of foraging birds is conducted from boats which approach within 50-100 m (e.g. see Perrow *et al.,* 2010).

Conclusion

7.5.1.39 Sandwich tern are not considered vulnerable to impacts associated with disturbance (Wade *et al.,* 2016). Activities associated with the construction of the Hornsea Three export cable are highly unlikely to impact areas with a high level of usage by Sandwich tern from the breeding colony at Blakeney Point, with these foraging areas protected as part of the Greater Wash pSPA. It is therefore assessed that there is no indication, of an adverse effect on the integrity of the Sandwich tern feature of the Greater Wash pSPA as a result of disturbance/displacement due to construction and decommissioning activities.

Changes to prey availability

7.5.1.40 The predicted usage of the Hornsea Three export cable route by Sandwich tern is considered to be low (Figure 7.5) with the majority of foraging areas used by Sandwich terns from Blakeney Point, including those of high usage, unaffected by construction activities associated with the Hornsea Three export cable route.

7.5.1.41 Numbers of Sandwich tern affected will depend on the overlap of such activity with food resources at any particular time. Moreover the above mentioned spatial and temporal parameters of the cable installation together with the findings of Environmental Statement volume 2, chapter 3: Fish and Shellfish Ecology indicate that the relevant significance of effects of construction impacts on prey species is no greater than minor, suggesting any potential impact from construction would affect only a limited number of Sandwich terns.

7.5.1.42 Sandwich tern feed on small fish, including sandeel, herring and sprat (Cramp & Simmons 1977 - 1994). Environmental Statement colume 2, chapter 3: Fish and Shellfish Ecology assessed the potential effects of construction impacts on the prey species of Sandwich tern and determined that these impacts represented a significance of no more than minor. Sandwich tern is considered to have a moderate habitat use flexibility meaning that the species is, to some extent, able to respond to changes in habitat conditions (Wade *et al.,* 2016).

Conclusion

7.5.1.43 As it has been identified that there is limited temporal span and localised level effect of export cable installation, in addition to the determined relatively low usage of the export cable route by Sandwich tern and insignificant effects on their prey resources, it is assessed that there is no indication, of an adverse effect on the integrity of the feature of the Greater Wash pSPA as a result of changes to prey availability caused by construction and decommissioning activities.

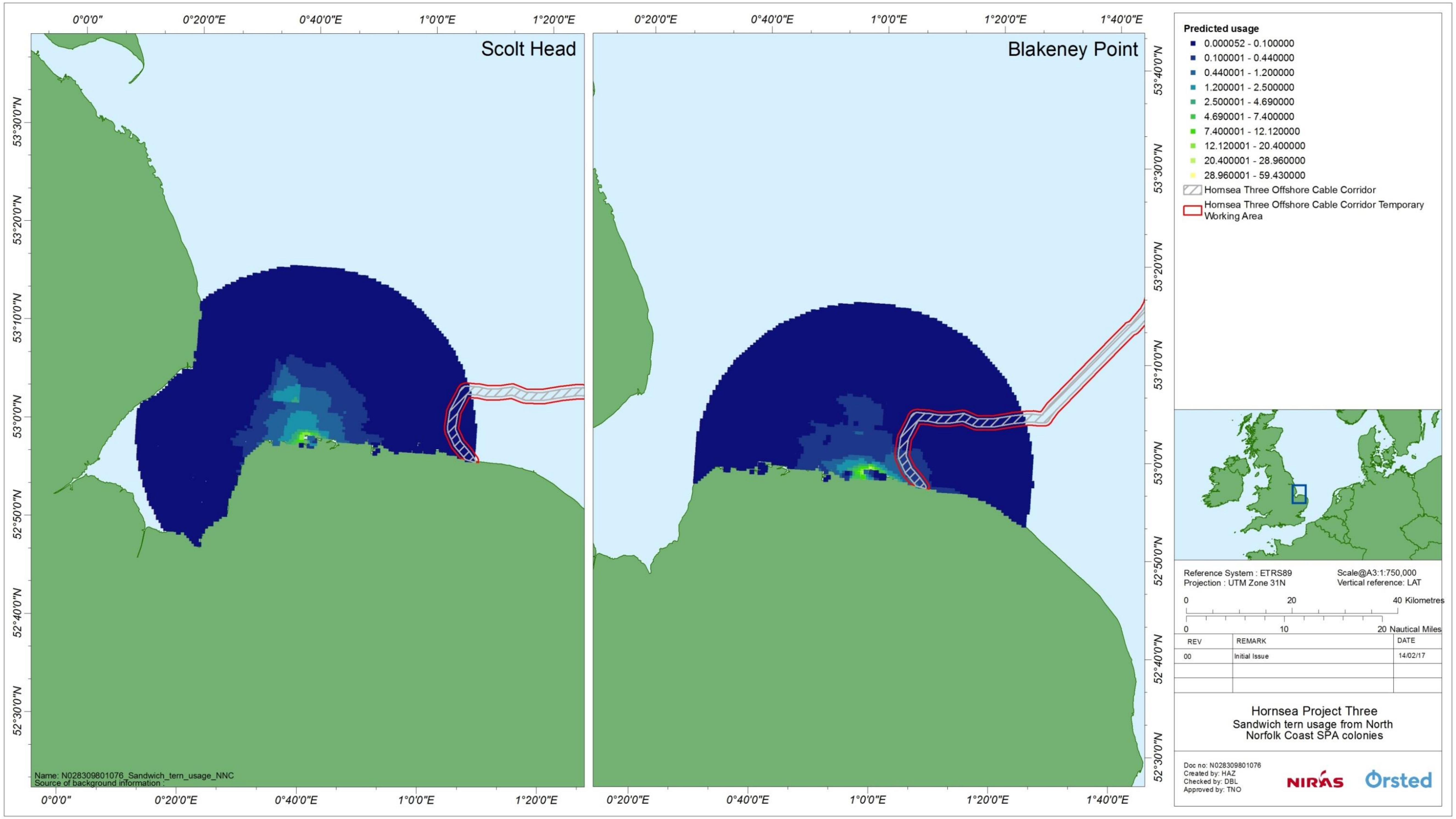


Figure 7.5: Predicted usage of offshore areas along the North Norfolk Coast by Sandwich terns from the breeding colonies at Scolt Head and Blakeney Point (data obtained from Natural England)

7.5.2 FFC pSPA/ Flamborough Head and Bempton Cliffs SPA from the Project

Site description

7.5.2.1 The FFC pSPA is a proposed extension to the existing Flamborough Head and Bempton Cliffs SPA located on the central Yorkshire coast. The existing SPA, which is 149 km from Hornsea Three, consists of sea cliffs up to 135 m in height and cliff top grassland. The proposed extension will incorporate coastal cliffs between Filey Brigg and Cunstone Nab and a 2 km marine extension around the full extent of the existing SPA. The existing SPA is designated for kittiwake (83,700 pairs). The proposed SPA citation will have a designated kittiwake population of 44,520 pairs and in addition will incorporate a further three species, gannet (8,469 pairs), guillemot (41,607 pairs) and razorbill (10,570 pairs), and a breeding seabird assemblage of 215,750 individuals. As part of a breeding seabird assemblage the pSPA also supports 1,447 pairs of fulmar (a listed component of the assemblage) and 980 pairs of puffin (a non-listed component of the assemblage).

Features screened into assessment

7.5.2.2 The screening assessment identified the potential for LSE on the following features of this pSPA:

- Fulmar (displacement in the breeding, post-breeding, non-breeding and pre-breeding seasons);
- Gannet (collision and displacement in the breeding, pre-breeding and post-breeding seasons (adult birds));
- Puffin (displacement in the breeding and non-breeding seasons (all birds));
- Guillemot (displacement in the breeding season (immature birds) and non-breeding season (all birds));
- Razorbill (displacement in the breeding season (immature birds) and non-breeding season (all birds)); and
- Kittiwake (collision in the breeding, pre-breeding and post-breeding seasons (adult birds)).

7.5.2.3 Potential impacts on immature gannet and kittiwake are not quantified in the following assessments with any impacts on immature birds calculated as part of population modelling (if this is considered necessary as part of the assessments presented) based on the level of impact apportioned to the breeding adult population. This is the approach previously applied in population modelling (Hornsea Project Two) and is considered appropriate for these species at Hornsea Three.

7.5.2.4 For the three auk species, direct consideration of the impacts of immature birds is presented as it is considered that no breeding adult birds of these species will be present at Hornsea Three and therefore, if population modelling were to be required, the level of immature impact could not be calculated based on the impact on breeding adult birds as the input for this would be zero. The impact on immature birds is considered using a qualitative approach due to the complexities of identifying immature populations and the contribution of different breeding colonies to this population.

7.5.2.5 A summary of the screening process is presented in Table 7.8.

Table 7.8: Results of the screening process with respect to the FFC pSPA.

Feature	Project Phase	Potential Impact	Likely Significant Effect
Fulmar	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Yes
		Changes to prey availability	No
Gannet	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	Potential for LSE
		Displacement	Potential for LSE
		Changes to prey availability	No
Puffin	Construction/decommissioning	Disturbance	Potential for LSE
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Potential for LSE
		Changes to prey availability	No
Guillemot	Construction/decommissioning	Disturbance	Potential for LSE
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Potential for LSE
		Changes to prey availability	No
Razorbill	Construction/decommissioning	Disturbance	Potential for LSE
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Potential for LSE
		Changes to prey availability	No
Kittiwake	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	Potential for LSE
		Displacement	No
		Changes to prey availability	No
	Operation	Collision risk	Potential for LSE
		Displacement	No

Feature	Project Phase	Potential Impact	Likely Significant Effect
		Changes to prey availability	No

Fulmar

7.5.2.6 Fulmar is included as a listed assemblage feature as part of the designation for the FFC pSPA with a population of 1,447 pairs as detailed in the Departmental Brief for the pSPA (Natural England 2014b).

7.5.2.7 Fulmar have an extensive foraging range in the breeding season with Thaxter *et al.* (2012) reporting a mean-maximum foraging range of 400 (±245.8) km. This therefore suggests connectivity between birds from FFC pSPA and Hornsea Three. In addition to FFC pSPA there are also further colonies located on the east coast of the UK from which the foraging range of fulmar interacts with Hornsea Three.

7.5.2.8 In order to identify the contribution of FFC pSPA to the population that may interact with Hornsea Three, colony counts from all colonies that could contribute birds to the population interacting with Hornsea Three were sourced from the Seabird Monitoring Programme (SMP) database (JNCC, 2017c). This provided a regional breeding population comprising of 11,745 birds with this representing a total of the counts for each colony most contemporaneous with the Hornsea Three aerial surveys. Of this population FFC pSPA represents 21.3%. The calculation of this proportion assumes equal mixing of birds from these colonies in the North Sea, an assumption that is likely to underestimate the apportioned impact to FFC pSPA. However, there is likely to be a significant population of immature (especially those of four years and older (Furness, 2015) and non-breeding birds present in the North Sea during the breeding season which would lead to the apportioning value for FFC pSPA being an over-estimate. As such the apportioning value calculated for the breeding season is considered appropriate and precautionary.

7.5.2.9 For the post-and pre-breeding seasons (autumn and spring) the BDMPS population from Furness (2015) is 957,502 individuals of which 0.18% are from the colony at FFC pSPA.

7.5.2.10 In the non-breeding season (winter), the BDMPS population is an estimated 568,736 individuals (Furness, 2015) of which 0.22% are from the colony at FFC pSPA.

7.5.2.11 Based on the above calculations, the following apportioning values will be applied in assessments for fulmar at Hornsea Three:

- Breeding season = 21.3%
- Post-breeding season = 0.18%
- Non-breeding season = 0.22%
- Pre-breeding season = 0.18%

<u>Operation/maintenance</u>

Displacement

7.5.2.12 Wade *et al.* (2016) identifies fulmar as a species with a very low vulnerability to displacement impacts although states that there is a high degree of uncertainty associated with this score. It has proved difficult to obtain evidence relating to potential displacement impacts on fulmar with studies often limited by the number of fulmar observed (e.g. Leopold *et al*. (2011)). Vanmerman *et al.* (2017) did not identify a significant effect on fulmar at the Thorntonbank offshore wind farm with Krijgsveld *et al*. (2011) calculating a displacement rate of 28%. In contrast Barton *et al.* (2009) noted significant declines in the abundance of fulmar at the Arklow Bank wind farm although these declines also appeared to occur across the entire study area used for the study.

7.5.2.13 There was no significant effect on the abundance of fulmar at the Thortonbank offshore wind farm between the pre-construction and operational phases (Vaneman *et al.,* 2017). Leopold *et al.* (2011) was unable to draw conclusive results at Egmond aan Zee due to low numbers of birds although Krijgsveld *et al*. (2011), using data collected at the same project, identified fulmar as a lower sensitivity species with a displacement rate of 28%. Barton *et al.* (2009) noted "*highly significant*" declines in the abundance of fulmar at the Arklow Bank wind farm although declines appear to have occurred across the study area.

7.5.2.14 In light of the limited information available on the likely displacement impacts on fulmar, a displacement range of 10-30% from the Hornsea Three and 2 km buffer during the breeding and non-breeding seasons (post-, non- and pre-breeding seasons) is highlighted for focus in terms of the assessment for fulmar (as agreed through the EWG see Consultation Report, Annex 1 Evidence Plan).

7.5.2.15 There is little or no evidence as to the likely mortality rates for a population impacted by displacement. For the purposes of this assessment, species-specific mortality rates for displaced breeding birds have been defined based on the behaviour of each species. For fulmar, mortality rates of 2% in the breeding season and 1% in the non-breeding seasons form the focus of the assessment. These rates are considered appropriate due to the large foraging range of the species (400 km; Thaxter *et al.* (2012)), the high habitat flexibility of the species (Wade *et al.,* 2016) and the wide availability of alternative foraging habitat.

<u>Breeding season</u>

7.5.2.16 The mean-peak fulmar population estimate within Hornsea Three and 2 km buffer during the breeding season (April-August) that can be apportioned to the pSPA is 303 birds. Displacement analysis for fulmar predicts mortality of up to two fulmars in the breeding season based on a displacement rate range of 10-30% and a mortality rate of 2% (Table 7.14). Therefore, birds lost to the population as a result of displacement represent 0.02-0.06% of the pSPA breeding population (1,447 pairs) and would result in a 0.33-0.98% increase in background mortality (185 individuals).

Table 7.9: Predicted fulmar mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the breeding season.

Displaced (%)	Mortality rate (%)												
	1	*2*	*5*	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*
10	0	1	2	3	6	9	12	15	18	21	24	27	30
20	1	1	3	6	12	18	24	30	36	42	48	55	61
30	1	2	5	9	18	27	36	45	55	64	73	82	91
40	1	2	6	12	24	36	48	61	73	85	97	109	121
50	2	3	8	15	30	45	61	76	91	106	121	136	151
60	2	4	9	18	36	55	73	91	109	127	145	164	182
70	2	4	11	21	42	64	85	106	127	148	170	191	212
80	2	5	12	24	48	73	97	121	145	170	194	218	242
90	3	5	14	27	55	82	109	136	164	191	218	245	273
100	3	6	15	30	61	91	121	151	182	212	242	273	303

Key: < 1% background mortality | > 1% background mortality/<1% SPA population | > 1% SPA population

Post-breeding season

7.5.2.17 The mean-peak fulmar population estimate calculated for Hornsea Three and 2 km buffer during the post-breeding season that can be apportioned to the pSPA is two birds. Displacement analysis for fulmar predicts mortality of less than one bird in the post-breeding season based on a displacement rate range of 10-30% and a mortality rate of 1% (Table 7.10).

Table 7.10: Predicted fulmar mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the post-breeding season.

Displaced (%)	Mortality rate (%)												
	1	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	0	0	0	0	0	0	0	0	1	1	1	1
50	0	0	0	0	0	0	0	0	1	1	1	1	1
60	0	0	0	0	0	0	0	1	1	1	1	1	1
70	0	0	0	0	0	0	1	1	1	1	1	1	1
80	0	0	0	0	0	0	1	1	1	1	1	1	1
90	0	0	0	0	0	0	1	1	1	1	1	1	2
100	0	0	0	0	0	1	1	1	1	1	1	2	2

Key: < 1% background mortality | > 1% background mortality/<1% SPA population | > 1% SPA population

Non-breeding season

7.5.2.18 The mean-peak fulmar population estimate calculated for Hornsea Three and 2 km buffer during the non-breeding season that can be apportioned to the pSPA is one bird. Displacement analysis for fulmar predicts mortality of less than one bird in the non-breeding season based on a displacement rate range of 10-30% and a mortality rate of 1% (Table 7.15).

Table 7.11: Predicted fulmar mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the non-breeding season.

Displaced (%)	Mortality rate (%)												
	1	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	1
80	0	0	0	0	0	0	0	0	0	0	0	1	1
90	0	0	0	0	0	0	0	0	0	0	1	1	1
100	0	0	0	0	0	0	0	0	0	1	1	1	1

Key: < 1% background mortality | > 1% background mortality/<1% SPA population | > 1% SPA population

Pre-breeding season

7.5.2.19 The mean-peak fulmar population estimate calculated for Hornsea Three and 2 km buffer during the pre-breeding season that can be apportioned to the pSPA is one bird. Displacement analysis for fulmar predicts mortality of less than one bird in the pre-breeding season based on a displacement rate range of 10-30% and a mortality rate of 1% (Table 7.12).

Table 7.12: Predicted fulmar mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the pre-breeding season.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	1	1
70	0	0	0	0	0	0	0	0	0	0	1	1	1
80	0	0	0	0	0	0	0	0	0	1	1	1	1
90	0	0	0	0	0	0	0	0	1	1	1	1	1
100	0	0	0	0	0	0	0	0	1	1	1	1	1

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

Conclusion

7.5.2.20 Due to the low percentage of the pSPA population affected by displacement and, the small increase in background mortality it is assessed that there is no adverse effect on the integrity of the fulmar population of the FFC pSPA as a result of displacement mortality due to operation and maintenance activities.

Gannet

7.5.2.21 The pSPA supports a growing population of breeding gannets, which, for the purpose of this assessment is assumed to comprise 8,469 pairs of breeding adults as detailed in the Departmental Brief for the pSPA (Natural England 2014b).

7.5.2.22 In each of the three years 2010-2012, adult gannets from Bempton Cliffs, a component of the pSPA, were fitted with satellite tags by RSPB to investigate their foraging ranges during chick-rearing and early post-breeding periods. This was undertaken in order to establish whether there was overlap with any proposed Round 3 Zones (Langston *et al.*, 2013). The study had the following objectives:

- to determine foraging ranges, flight directions, and foraging destinations of adult gannets from the breeding colony at Bempton Cliffs;
- to determine whether adult gannets from Bempton Cliffs forage within or pass through, on their way to foraging locations, the Round 3 zones of Dogger Bank, Hornsea and East Anglia; and
- to seek to obtain a measure of relative importance of the sea areas used.

7.5.2.23 The three seasons of study, in 2010 (n=14 birds), 2011 (n=13) and 2012 (n=15), showed tagged birds during the breeding season to coincide with the western half of the former Hornsea Zone in particular (with only occasional records from the Hornsea Three array area), and some birds recorded on Dogger Bank and a few records in the East Anglia Zone, as well as within the Greater Wash strategic area. Post-breeding locations overlapped with the Hornsea, Dogger Bank, and East Anglia zones before dispersal out of the North Sea or cessation of recording. The tags remained on the birds for between 6 to 132 days, which enabled tracking of the longest functioning tag to north-west Africa during autumn 2012.

7.5.2.24 The overall distribution of foraging locations during chick-rearing was broadly similar in all three years, although at higher density further out to sea in 2012 (Figure 7.6) (this is potentially in response to the poorer climatic conditions affecting prey during the 2012 breeding season). Most locations were within 200 km of Bempton Cliffs, with the highest density of locations mostly within 50-100 km. The mean foraging range was less than 50 km (maximum foraging range was within approximately 300-400 km), whilst the average foraging trip length was less than 150 km (maximum trip length ranged from approximately 1,200 - 1,700 km). Foraging trip duration was highly variable, on average lasting approximately eight hours.

7.5.2.25 It is evident from Figure 7.6 and the annual reports (Langston *et al.,* 2013) that the operational footprint of Hornsea Three may provide disturbance to a limited extent to foraging gannets from the pSPA. The distance of Hornsea Three from the colony is, however, well above the mean foraging range measured by Langston *et al.*(2013), and so it is unlikely that it forms a notably important foraging area for this species.

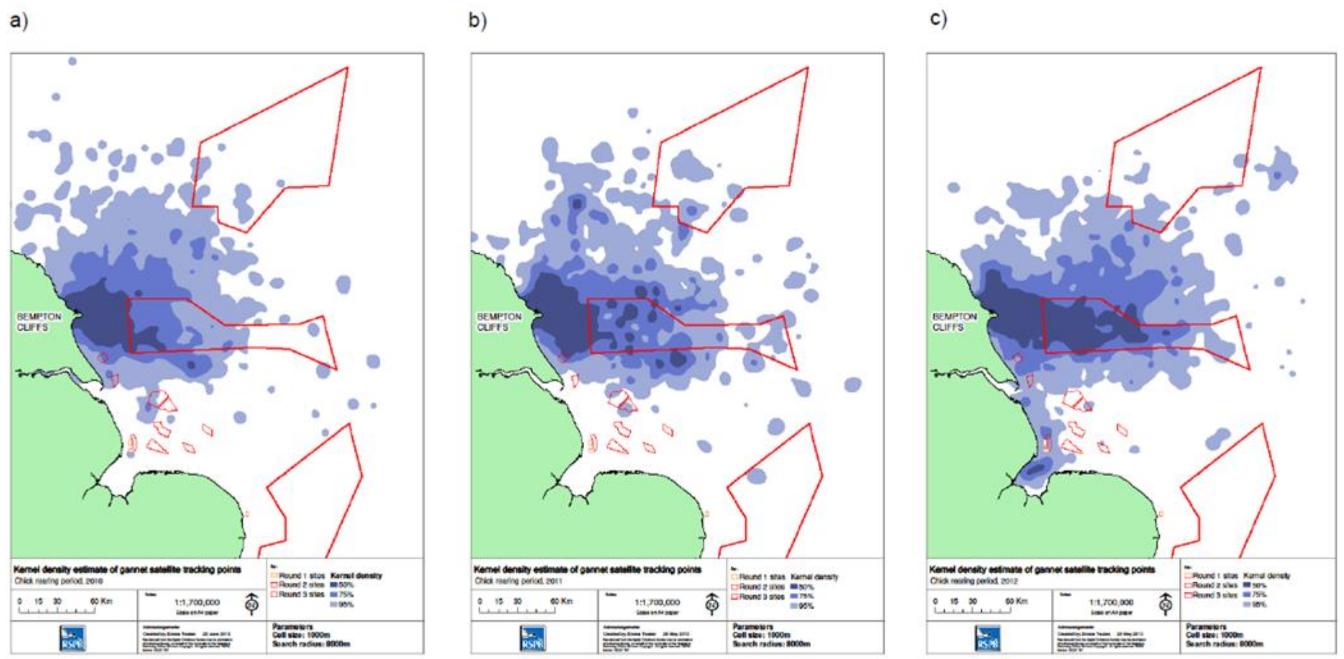


Figure 7.6: Gannet foraging Kernel Density Estimation (kernel density tool, ArcGIS Desktop 10) from satellite-tagged birds from Bempton Cliffs breeding colony in 2010 (left), 2011 (middle) and 2012 (right) during the chick-rearing period, showing the 50%, 75% and 95% density contours. From Langston *et al*., (2013).

7.5.2.26 Age data collected during boat-based surveys of the former Hornsea Zone is considered to be the most suitable dataset from which to derive the proportion of adult birds present at Hornsea Three. These boat-based surveys were undertaken between March 2010 and February 2013 covering the entire former Hornsea Zone and providing age class data for nearly 19,000 gannets.

7.5.2.27 The proportions presented in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA, suggest that as distance from the FFC pSPA colony increases the proportion of adult birds present also decreases. This is illustrated by both the data associated with the Hornsea Zone transects (see Table 1.6 of Annex 03), where the adult proportion decreases from 78.5% to 40.4% and across the Hornsea Project One and Hornsea Project Two project areas where the adult proportion is 66.0% in the western side and 53.6% in the eastern side. As the Hornsea Zone transect data offshore (east) of Hornsea Project One and Hornsea Project Two covers Hornsea Three it is considered that this proportion is the most applicable for use when apportioning birds to FFC pSPA in the breeding season.

7.5.2.28 The post-breeding (autumn) BDMPS population from Furness (2015) is 456,299 individuals of which 4.8% are from the colony at FFC pSPA.

7.5.2.29 In the pre-breeding season (spring), the BDMPS population is an estimated 248,385 gannets (Furness, 2015). Gannets from FFC pSPA represent 6.2% of this population.

7.5.2.30 Based on the above and the calculations presented in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA, the following apportioning values will be applied in assessments for gannet at Hornsea Three:

- Breeding season = 40.4%
- Post-breeding season = 4.8%
- Pre-breeding season = 6.2%

7.5.2.31 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015)) are consistent with the approaches used in the assessments for previous offshore wind farm developments (e.g. Hornsea Project Two).

Operation/maintenance

Collision risk

7.5.2.32 Using the values detailed above, collision risk estimates calculated using the Band (2012) CRM have been apportioned to the FFC pSPA gannet population in Table 7.13.

Table 7.13: Gannet collision risk estimates apportioned to FFC pSPA.

Season	Predicted no. of collisions (no apportioning)			Apportioning value (%)	No. of collisions apportioned to pSPA		
	Option 1 (98.9% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)		Option 1 (98.9% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)
Breeding	8	18	7	40.4	3	7	3
Post-breeding	5	12	5	4.8	0	1	0
Pre-breeding	4	8	3	6.2	0	0	0
Total	17	37	15		4	8	3

7.5.2.33 Collision risk modelling, using Option 3, predicts a total collision risk mortality of 15 gannet at Hornsea Three across a full annual cycle (98% avoidance) with 3 of these apportioned to the pSPA. This represents 0.018% of the pSPA population (8,469 pairs) and 0.22% increase in baseline mortality (1,372 individuals). When using Option 2, a total collision risk mortality of 37 gannet is predicted (98.9% avoidance rate) where 8 are apportioned to the pSPA. This represents 0.05% of the pSPA population and a 0.6% increase in baseline mortality. Using Option 1, a total of 17 collisions/annum are predicted (98.9% avoidance rate) with 4 apportioned to the pSPA. This represents 0.02% of the pSPA population and a 0.3% increase in baseline mortality.

7.5.2.34 The degree of variability associated with the density data and avoidance rates used in collision risk modelling for gannet is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the FFC pSPA population of gannet (see monthly collision risk values presented in Environmental Statement, Tables A.1, A.3 and A.5 in Annex 5.3: Collision Risk Modelling). The greatest degree of variability in the collision risk estimates for gannet is caused by the flight height data (see monthly collision risk values presented in Tables A.2, A.4 and A.6 in Annex 5.3: Collision Risk Modelling), with the 1% threshold of baseline mortality for the regional breeding population of gannet surpassed when considering the variability associated with flight height data when using Option 2. However, the collision risk estimates predicted using Option 2 (and Option 3) use flight height data that is not necessarily representative of the behaviour of birds at Hornsea Three with this illustrated by the site-specific data for Hornsea Three collected as part of the boat-based survey programme for the applications for the Hornsea Projects One and Two offshore wind farms. The PCH value calculated using site-specific data (1.4%) is much lower than that derived from generic flight height data (4.0%).

<u>Conclusion</u>

7.5.2.35 Due to the low percentage of the pSPA population affected by collision and, the small increase in background mortality it is assessed that there is no adverse effect on the integrity of the gannet population of the FFC pSPA as a result of collision mortality due to operation and maintenance activities.

Displacement

7.5.2.36 Despite the wide foraging range of the species, Krijgsveld *et al.* (2010; 2011) have shown that gannets in flight strongly avoid wind farms, albeit relatively close to turbines (within 500 m). A displacement rate (50%) was estimated from raw data for the first year of operation at Robin Rigg Offshore Wind Farm (Walls *et al.*, 2013), simple modelling found a decrease in numbers on the sea (pre vs. post-construction) but not for birds in flight. However, in light of the limited information available, a displacement range of 30-70% from the Hornsea Three and 2 km buffer during the breeding and non-breeding seasons (post-breeding and pre-breeding seasons) is highlighted for focus in terms of the assessment for gannet (as agreed through the EWG see Consultation Report, Annex 1 Evidence Plan).

7.5.2.37 There is little or no evidence as to the likely mortality rates for a population impacted by displacement. For the purposes of this assessment, species-specific mortality rates for displaced breeding birds have been defined based on the behaviour of each species. For gannet, mortality rates of 2% in the breeding season and 1% in the non-breeding season form the focus of the assessment. These rates are considered appropriate due to the large foraging range of the species and the wide availability of alternative foraging habitat.

<u>Breeding season</u>

7.5.2.38 The mean-peak gannet population estimate within Hornsea Three and 2 km buffer during the breeding season (April-August) that can be apportioned to the pSPA is 539 birds. Displacement analysis for gannet predicts mortality of three to eight gannet in the breeding season based on a displacement rate range of 30-70% and a mortality rate of 2% (Table 7.14). Therefore birds lost to the population as a result of displacement represent 0.02-0.04% of the pSPA breeding population (8,469 pairs) and would result in a 0.24-0.55% increase in background mortality (1,372 individuals).

Table 7.14: Predicted gannet mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the <u>breeding season</u>.

	Mortality rate (%)												
Displaced (%)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	1	1	3	5	11	16	22	27	32	38	43	48	54
20	1	2	5	11	22	32	43	54	65	75	86	97	108
30	2	3	8	16	32	48	65	81	97	113	129	145	162
40	2	4	11	22	43	65	86	108	129	151	172	194	216
50	3	5	13	27	54	81	108	135	162	189	216	242	269
60	3	6	16	32	65	97	129	162	194	226	259	291	323
70	4	8	19	38	75	113	151	189	226	264	302	339	377
80	4	9	22	43	86	129	172	216	259	302	345	388	431
90	5	10	24	48	97	145	194	242	291	339	388	436	485
100	5	11	27	54	108	162	216	269	323	377	431	485	539

Key:
- < 1% background mortality
- > 1% background mortality/<1% SPA population
- > 1% SPA population

<u>Post-breeding season</u>

7.5.2.39 The mean-peak gannet population estimate calculated for Hornsea Three and 2 km buffer during the post-breeding season that can be apportioned to the pSPA is 48 birds. Displacement analysis for gannet predicts mortality of less than one gannet in the post-breeding season based on a displacement rate range of 30-70% and a mortality rate of 1% (Table 7.15).

Table 7.15: Predicted gannet mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the post-breeding season.

	Mortality rate (%)												
Displaced (%)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	0	1	1	2	2	3	3	4	4	5
20	0	0	0	1	2	3	4	5	6	7	8	9	10
30	0	0	1	1	3	4	6	7	9	10	11	13	14
40	0	0	1	2	4	6	8	10	11	13	15	17	19
50	0	0	1	2	5	7	10	12	14	17	19	21	24
60	0	1	1	3	6	9	11	14	17	20	23	26	29
70	0	1	2	3	7	10	13	17	20	23	27	30	33
80	0	1	2	4	8	11	15	19	23	27	31	34	38
90	0	1	2	4	9	13	17	21	26	30	34	39	43
100	0	1	2	5	10	14	19	24	29	33	38	43	48

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

Pre-breeding season

7.5.2.40 The mean-peak gannet population estimate within Hornsea Three and 2 km buffer during the pre-breeding season that can be apportioned to the pSPA is 25 birds. Displacement analysis for gannet predicts mortality of less than one gannet in the pre-breeding season based on a displacement rate range of 30-70% and a mortality rate of 1% (Table 7.16).

Table 7.16: Predicted gannet mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the pre-breeding season.

	Mortality rate (%)												
Displaced (%)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	0	1	1	1	1	2	2	2	2	3
20	0	0	0	1	1	2	2	3	3	4	4	5	5
30	0	0	0	1	2	2	3	4	5	5	6	7	8
40	0	0	1	1	2	3	4	5	6	7	8	9	10
50	0	0	1	1	3	4	5	6	8	9	10	11	13
60	0	0	1	2	3	5	6	8	9	11	12	14	15
70	0	0	1	2	4	5	7	9	11	12	14	16	18
80	0	0	1	2	4	6	8	10	12	14	16	18	20
90	0	0	1	2	5	7	9	11	14	16	18	21	23
100	0	1	1	3	5	8	10	13	15	18	20	23	25

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

Conclusion

7.5.2.41 Due to the low percentage of the pSPA population affected by displacement (with no pSPA birds affected in the pre- and post-breeding seasons), the small increase in background mortality and the extensive foraging range of gannet it is assessed that there is no adverse effect on the integrity of the gannet population of the FFC pSPA as a result of displacement due to operation and maintenance activities.

Kittiwake

7.5.2.42 Kittiwake was rated as having relatively high vulnerability to collision impacts by Wade *et al.* (2016), due to the proportion of flights likely to occur at potential risk height and percentage of time in flight. From previous studies in Flanders that have recorded mortality rates and collision rates, estimated micro-avoidance rates were, however, high for smaller gulls (Everaert, 2006; 2008; 2011; Everaert *et al*., 2002; Everaert and Kuijken, 2007). Studies have also shown that rates are consistently above 98% for flights at rotor height (GWFL, 2011). The recently published report for Marine Scotland (Cook *et al.*, 2014) considers that a 99.2% avoidance rate is appropriate for the 'Basic' Band Model.

7.5.2.43 The FFC pSPA is the closest breeding colony for kittiwake to Hornsea Three. However, Hornsea Three is outside of the mean-maximum (± 1 SD) foraging range of kittiwake (60 km) from the pSPA when applying the foraging ranges reported by Thaxter *et al.* (2012). Preliminary results from the FAME project which has tracked breeding kittiwake from the FFC pSPA colony does however suggest that there may be limited connectivity between the pSPA and Hornsea Three.

7.5.2.44 Whilst it is possible to distinguish first year kittiwake from older birds, it is not possible to reliably separate other immature birds from adult birds. Nor is it possible to separate, visually, breeding and non-breeding adult birds.

7.5.2.45 Data from aerial surveys undertaken for Hornsea Three and boat-based surveys undertaken for the former Hornsea Zone have both been analysed to provide information on the age structure of kittiwake at Hornsea Three. A full review of these data sources are provided in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA. Boat-based surveys conducted across the former Hornsea Zone provide information on over 122,000 kittiwake of which 37% were aged. The Hornsea Three aerial surveys recorded 4,803 kittiwakes of which 39% were aged. Based on the analyses and information presented in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA it was considered that adults will comprise no more than 41.7% of the individuals observed at Hornsea Three. This proportion is based on the analyses presented in Annex 3: Phenology, connectivity and apportioning for features of the FFC pSPA which accounts for the presence of immature birds that cannot be identified during surveys (i.e. those of 2 years and older). In addition, the use of 41.7% is considered appropriate for the following reasons:

- Cumulative foraging range data (presented in Annex 3: Phenology, connectivity and apportioning for features of the FFC pSPA) indicates that very few foraging trips (if any) would occur at a distance beyond 120 km (the maximum foraging distance reported by Thaxter *et al.* (2012) (Hornsea Three is 149 km from FFC pSPA);
- When breeding productivity is high, foraging ranges are short (Hamer *et al.,* 1993; Lewis *et al.,* 2006; Riou *et al.,* 2006; Thaxter *et al.,* 2012). Breeding productivity at FFC pSPA is comparatively high suggesting that foraging ranges will be short;
- Based on the relationship between time constraints and breeding productivity, a number of studies have shown that the foraging ranges of kittiwake are unlikely to exceed 73 km (Daunt *et al.,* 2002; Coulson, 2011; Pearson (1968);
- At sea utilisation maps presented in Wakefield *et al.* (2017) derived utilising the tracking data used to inform the basis for connectivity between FFC pSPA and Hornsea Three suggest that the area in which Hornsea Three is located is beyond the 95% utilisation contour; and
- Site-specific flight direction data does not indicate movements of birds to and from the colony at FFC pSPA into Hornsea Three.

7.5.2.46 It is therefore considered that the proportion of adult birds present at Hornsea Three during the breeding season is 41.7%. This value is considered to be precautionary because it does not, for example, account for the following:

- The value does not account for adults in the population not breeding in a given year – this could account for a further reduction of c5-10% (Coulson, 2011; Marine Scotland Licensing Operations Team, 2017);
- A smaller proportion of first year birds are likely to be present in natal waters with a much greater proportion of older age classes of immature birds showing affinity with natal waters;
- FAME data indicates that the majority of foraging flights are close to the colony and data given by BirdLife (see Annex 3: Phenology, connectivity and apportioning for features of the FFC pSPA) suggests that only up to 5% of birds are likely to travel as far as Hornsea Three; and
- Immature birds are not likely to be evenly distributed within the North Sea and will show aggregations near to foraging resources. If the area within which Hornsea Three lies is seen to be notable for kittiwake foraging; immatures may be present in large numbers.

7.5.2.47 For apportioning in non-breeding seasons (post- and pre-breeding seasons), population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider population present within the North Sea.

7.5.2.48 In the post- and pre-breeding seasons the proportion of breeding adult birds assumed to be present in the observed population at Hornsea Three is 5.4% and 7.2% respectively based on the assumed contribution of the FFC pSPA to the relevant BDMPS populations (Furness 2015).

7.5.2.49 Based on the calculations presented Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA the following apportioning values will be applied in assessments for kittiwake at Hornsea Three:

- Breeding season = 41.7%
- Post-breeding season = 5.4%
- Pre-breeding season = 7.2%

7.5.2.50 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015)) are consistent with the approaches used in the assessments for previous offshore wind farm developments (e.g. Hornsea Project Two).

<u>Operation/maintenance</u>

Collision risk

7.5.2.51 An assessment of collision risk has been undertaken for kittiwake using Band (2012). The results for Options 1, 2 and 3 of this model are presented in Table 7.17.

Table 7.17: Kittiwake collision risk estimate apportioned to FFC pSPA

Season	Predicted no. of collisions (no apportioning)			Apportioning value (%)	No. of collisions apportioned to pSPA		
	Option 1 (99.2% avoidance rate)	Option 2 (99.2% avoidance rate)	Option 3 (98% avoidance rate)		Option 1 (99.2% avoidance rate)	Option 2 (99.2% avoidance rate)	Option 3 (98% avoidance rate)
Breeding [a]	17	88	42	41.7	7	37	18
Post-breeding	11	55	26	5.4	1	3	1
Pre-breeding	6	29	14	7.2	0	2	1
Total	33	173	83		8	42	20

a Note: the predicted collision mortality rate during the breeding season includes a substantial proportion of non-breeding birds that are not associated with the FFC pSPA. The breeding population against which this rate is compared in the breeding season, however, comprises only breeding adult birds.

7.5.2.52 Collision risk modelling, using Option 3, predicts a total collision risk mortality of 83 collisions/annum at Hornsea Three across a full annual cycle (98% avoidance) with 20 of these apportioned to the pSPA. This represents 0.02% of the pSPA population (44,520 pairs) and 0.15% increase in baseline mortality (13,000 individuals). When using Option 2, a total collision risk mortality of 173 collisions/annum is predicted (99.2% avoidance rate) where 42 are apportioned to the pSPA. This represents 0.05% of the pSPA population and a 0.32% increase in baseline mortality. Using Option 1, a total of 33 collisions/annum are predicted (99.2% avoidance rate) with 8 apportioned to the pSPA. This represents 0.01% of the pSPA population and a 0.06% increase in baseline mortality.

7.5.2.53 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for kittiwake is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the FFC pSPA population of kittiwake (see monthly collision risk values presented in Environmental Statement, Tables A.7, to A.12 in Annex 5.3: Collision Risk Modelling).

Conclusion

7.5.2.54 Due to the low percentage of the pSPA population affected by collision and the small increase in background mortality it is assessed that there is no adverse effect on the integrity of the kittiwake population of the FFC pSPA as a result of collision mortality due to operation and maintenance activities. Furthermore, it should be noted that the predicted collision rates are considered precautionary due to the likely presence of a significant number of non-breeding adult birds in the observed population at Hornsea Three.

Puffin

7.5.2.55 During the breeding season, the mean foraging range of breeding puffins from a colony is 4 km, while the mean maximum range is 105.4 km and highest maximum reported 200 km (Thaxter *et al*., 2012). This strongly supports the hypothesis that puffins in the Hornsea Three area in summer are likely to be predominantly over-summering young immature birds rather than breeding adults from the Humberside colonies (which are over 100 km from the Hornsea development). The RSPB FAME project has not provided any foraging range data for puffins at UK colonies, but it is likely that birds from colonies in areas where there is a severe shortage of food will travel further than those reported in Thaxter *et al*. (2012) which is based mainly on studies in colonies where breeding success was moderate to high. However, colonies on the east coast of England generally show high breeding success and have not been affected by dramatic food shortages experienced by populations in Shetland and Orkney. .

7.5.2.56 The mean-maximum foraging range (±1 standard deviation) from Thaxter *et al.* (2012) partially overlaps to a minimal extent with Hornsea Three only when 1 standard deviation is taken into account. This strongly suggests that there is very limited likelihood of connectivity between the colony and the Hornsea Three array area. However, in light of the possibility of a small number of individuals occasionally foraging out as far as Hornsea Three an LSE was not discounted during screening.

7.5.2.57 However, analysis of the likely age structure of the population, based on the number of observed first year birds, indicates that the proportion of adult breeding birds likely to be present at Hornsea Three is very small (Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). In addition the analysis undertaken does not incorporate the likelihood of a greater proportion of older age classes of immature birds showing affinity with the colony.

7.5.2.58 In the non-breeding season, population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider non-breeding population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

7.5.2.59 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the non-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of puffin was calculated as 231,958 individuals. The contribution of breeding birds from FFC pSPA to this population is 0.4%.

Construction/decommissioning/operation

Disturbance/displacement

7.5.2.60 It is assumed that displacement resulting from operational activities of Hornsea Three presents the worst case scenario with respect to overall disturbance impacts on puffin. Therefore, the analysis of disturbance during construction/decommissioning is treated equivalently to the assessment of displacement presented below.

7.5.2.61 With regards to displacement and mortality rates that form the focus of the assessment due to the moderate sensitivity of the species, 50% displacement and 2-10% mortality is considered appropriately precautionary for the breeding season. For the non-breeding season, 50% displacement and 1% mortality is highlighted.

Breeding season

7.5.2.62 The total displacement mortality predicted in the breeding season is 3-13 birds when applying a 50% displacement and 2-10% mortality rate. It is considered that no breeding adults from the FFC pSPA will be present at Hornsea Three during the breeding season (see Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). Therefore all mortality is predicted to be attributable to either immature or non-breeding birds. Unlike breeding adult birds, immature birds are not constrained to certain areas during the breeding season and as such it is considered that the appropriate mortality rate is towards the lower end of the range presented.

7.5.2.63 Immature birds are known to visit colonies before age at first breeding (Harris and Wanless, 2011), however, as Hornsea Three is located a considerable distance from any breeding colony, the immature population structure at a breeding colony may not be reflected at Hornsea Three. It is however, considered that the immature population that may occur at Hornsea Three could consist of birds from colonies around the UK, with birds likely to visit multiple colonies before age at first breeding (Harris and Wanless, 2011). Despite this, it is considered likely that a large proportion of the immature population at Hornsea Three will originate from those breeding colonies that are closest to Hornsea Three including FFC pSPA, the Farne Islands (39,962 occupied burrows in 2013), Coquet Island (12,344 occupied burrows in 2013) and the Firth of Forth (51,991 equivalent pairs in 2013). These breeding colonies are much larger than FFC pSPA (980 pairs) and as such would have larger associated populations of immature birds. Therefore any apportioning of impacts from Hornsea Three to the total population of immatures present at Hornsea Three would result in a negligible proportion being apportioned to FFC pSPA.

7.5.2.64 In addition to immature birds, non-breeding birds are likely to be present at Hornsea Three. However, it is not known how large any such population would be, with estimates suggesting that between 1 and 20% of birds may skip a breeding season (Harris and Wanless, 2011). Although it is not possible to quantify how many non-breeding birds may be present, the presence of these birds will further dilute the impact that can be attributed to FFC pSPA.

7.5.2.65 In conclusion, less than one breeding adult associated with the breeding colony at the FFC pSPA is expected to be present at Hornsea Three in the breeding season (see Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). As a result the population present at Hornsea Three will be composed of immature and non-breeding birds of which FFC pSPA is likely to make a negligible contribution when the likely total immature population that may interact with Hornsea Three is considered. As a result a negligible proportion of the total impact is likely to be apportioned to FFC pSPA. There is therefore considered to be no risk from displacement effects during this season on the population of puffin at the pSPA.

Non-breeding season

7.5.2.66 The mean-peak puffin population estimate calculated for Hornsea Three and 2 km buffer during the non-breeding season that can be apportioned to the pSPA is one bird. Displacement analysis for puffin predicts mortality of less than one puffin in the non-breeding season based on a displacement rate of 50% and a mortality rate of 1% (Table 7.18). Therefore no birds would be lost to the pSPA population as a result of displacement in this season.

7.5.2.67 For immature birds, displacement analysis predicts mortality of less than one immature puffin in the non-breeding season based on a displacement rate of 50% and a mortality rate of 1%.

Conclusion

7.5.2.68 There is no predicted mortality of breeding adult puffin associated with the breeding colony of the FFC pSPA as a result of displacement from Hornsea Three in any biological season. In addition, any impact on immature birds associated with FFC pSPA is likely to be negligible. There is, therefore, no indication of an adverse effect on the puffin breeding feature at FFC pSPA as a result of disturbance or displacement due to operation and maintenance activities.

Table 7.18: Predicted puffin mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the non-breeding season

	Mortality rate (%)												
Displaced (%)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0

	Mortality rate (%)												
90	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	1

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

Razorbill

7.5.2.69 During the breeding season, the mean foraging range of breeding razorbills is considered to be in the region of 23.7 km, while the mean-maximum range is 48.5 km and highest maximum reported 95 km (Thaxter *et al.*, 2012). This strongly supports the hypothesis that any razorbills at Hornsea Three in summer are likely to be over-summering young immature birds originating from various colonies along the east coast of England and Scotland, rather than breeding adults from the Humberside colonies (which are over 100 km from Hornsea Three).

7.5.2.70 The RSPB FAME project tracked breeding adult razorbills from several colonies where breeding success was good: Bardsey (Wales) in 2011, Colonsay (west Scotland) in 2010 and 2011, and Puffin Island (Wales) in 2011. These birds showed similar results to those summarised in Thaxter *et al.*, (2012), with maximum ranges of around 60 km to 120 km. However, birds tracked from colonies in Orkney and Shetland, where breeding success was close to zero due to shortage of food, ranged much greater distances in these extreme conditions when chicks were starving. Such extreme conditions do not apply at colonies on the east coast of England, where breeding success is generally good (see Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA for further information).

7.5.2.71 Based on the information summarised above, it was therefore considered that there is no potential for connectivity and no potential for a LSE on the pSPA razorbill feature during the breeding season.

7.5.2.72 Breeding razorbill colonies in the UK are deserted in August, with modal departure in July (Pennington *et al*., 2004; Forrester *et al*., 2007). Breeding adults may desert colonies earlier than this in years when there is severe food shortage. Breeding failures in Shetland and Orkney may result in birds abandoning the colony as early as May or June, but those birds probably remain further north than the former Hornsea Zone immediately following breeding failure. During late summer and early autumn (July and August) when fledged young are completing growth at sea and adults are undertaking their post-breeding moult, most recoveries of UK ringed adults and juveniles also occur close to the colony, though by this time immature birds may be further afield (Wernham *et al*., 2002). During September, breeders and juveniles move predominantly southwards, with recoveries from southern Norway to Portugal, and predominantly in the southern North Sea, Celtic Sea, English Channel or Bay of Biscay (Wernham *et al*., 2002).

7.5.2.73 For apportioning in non-breeding seasons (post-, non- and pre-breeding seasons), population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

7.5.2.74 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the post-breeding and pre-breeding (migration) seasons as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of razorbill was calculated as 592,641 individuals. The contribution of breeding birds from FFC pSPA to this population is 3.4%.

7.5.2.75 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the non-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of razorbill was calculated as 218,708 individuals. The contribution of breeding birds from FFC pSPA to this population is 2.7%.

7.5.2.76 The following apportioning values will be applied in assessments for razorbill at Hornsea Three:

- Breeding season = N/A
- Post-breeding season = 3.4%
- Non-breeding season = 2.7%
- Pre-breeding season = 3.4%

<u>Construction/decommissioning/operation</u>

Disturbance/displacement

7.5.2.77 It is assumed that displacement resulting from operational activities of Hornsea Three presents the worst case scenario with respect to overall disturbance impacts on razorbill. Therefore, the analysis of disturbance during construction/decommissioning is treated equivalently to the assessment of displacement presented below.

7.5.2.78 In a number of studies of operational displacement, it has been observed that razorbills follow the same behaviours as do guillemots, with analysis often combining auk species together. At Robin Rigg for example, a 30% displacement rate was estimated when combining all auk species (Walls *et al*., 2013). For assessment purposes, a displacement value of 40% from the Hornsea Three and a 2 km buffer during the breeding, post-breeding and non-breeding seasons has been used for razorbill reflecting a degree of precaution based on a lower level of empirical evidence compared to other species. Mortality rates of 2-10% (breeding season), 2% (post- and pre-breeding seasons) and 1% (non-breeding season) are highlighted for assessment focus.

Breeding season

7.5.2.79 A total displacement impact of 5-25 birds is predicted in volume 2, chapter 5: Offshore Ornithology for razorbill in the breeding season using a displacement rate of 40% and a mortality rate range of 2-10%.. There is considered to be no connectivity between breeding adults from FFC pSPA and Hornsea Three and as such the total displacement impact will affect immature and non-breeding birds only. Unlike breeding adult birds, immature birds are not constrained to certain areas during the breeding season and as such it is considered that the appropriate mortality rate is towards the lower end of the range presented.

7.5.2.80 Immature birds are known to visit colonies before age at first breeding (Furness, 2015), however, as Hornsea Three is located a considerable distance from any breeding colony, the immature population structure at a breeding colony may not be reflected at Hornsea Three. It is however, considered that the immature population that may occur at Hornsea Three could consist of birds from colonies around the UK, with birds likely to visit multiple colonies before age at first breeding.

7.5.2.81 It is considered likely that a large proportion of the immature population present at Hornsea Three will originate from those breeding colonies that are closest to Hornsea Three including FFC pSPA, the Farne Islands (491 occupied sites in 2016), St Abb's to Fast Castle SPA (1,385 pairs in 2016) and the Firth of Forth (3,597 equivalent pairs in 2015). These breeding colonies are smaller than FFC pSPA (10,570 pairs) however, will dilute the impact that can be apportioned to the population of immatures associated with FFC pSPA. In addition there is likely to be a proportion of the population that is associated with other breeding colonies. Therefore any apportioning of impacts from Hornsea Three to the population of immatures present at Hornsea Three would result in a negligible proportion being apportioned to FFC pSPA.

7.5.2.82 In addition to immature birds, non-breeding birds are likely to be present at Hornsea Three. However, it is not known how large any such population would be. There is no evidence to suggest what proportion of a razorbill population may skip a breeding season however, evidence for a similar species (guillemot) suggests that approximately 7% of a population may skip a breeding season. Although it is not possible to quantify how many non-breeding birds may be present, the presence of these birds will further dilute the impact that can be attributed to FFC pSPA.

Post-breeding season

7.5.2.83 The mean-peak razorbill population estimate calculated for Hornsea Three and 2 km buffer during the post-breeding season that can be apportioned to the pSPA is 68 birds. Displacement analysis predicts mortality of one razorbill in the post-breeding season based on a displacement rate of 40% and a mortality rate of 2% (Table 7.19).

7.5.2.84 For immature birds, displacement analysis predicts mortality of less than one immature razorbill in the post-breeding season based on a displacement rate of 50% and a mortality rate of 1%.

Table 7.19: Predicted razorbill mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the post-breeding season.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	1	1	2	3	3	4	5	5	6	7
20	0	0	1	1	3	4	5	7	8	10	11	12	14
30	0	0	1	2	4	6	8	10	12	14	16	18	20
40	0	1	1	3	5	8	11	14	16	19	22	25	27
50	0	1	2	3	7	10	14	17	20	24	27	31	34
60	0	1	2	4	8	12	16	20	25	29	33	37	41
70	0	1	2	5	10	14	19	24	29	33	38	43	48
80	1	1	3	5	11	16	22	27	33	38	44	49	55
90	1	1	3	6	12	18	25	31	37	43	49	55	61
100	1	1	3	7	14	20	27	34	41	48	55	61	68

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

Non-breeding season

7.5.2.85 The peak razorbill population estimate within Hornsea Three and 2 km buffer during the non-breeding season that can be apportioned to the pSPA is 100 birds. Displacement analysis predicts mortality of less than one razorbill in the non-breeding season based on a displacement rate of 40% and a mortality rate of 1% (Table 7.20).

7.5.2.86 For immature birds, displacement analysis predicts mortality of less than one immature razorbill in the non-breeding season based on a displacement rate of 50% and a mortality rate of 1%.

Table 7.20: Predicted razorbill mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the non-breeding season.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	1	2	3	4	5	6	7	8	9	10
20	0	0	1	2	4	6	8	10	12	14	16	18	20
30	0	1	2	3	6	9	12	15	18	21	24	27	30
40	0	1	2	4	8	12	16	20	24	28	32	36	40

	Mortality rate (%)												
50	1	1	3	5	10	15	20	25	30	35	40	45	50
60	1	1	3	6	12	18	24	30	36	42	48	54	60
70	1	1	4	7	14	21	28	35	42	49	56	63	70
80	1	2	4	8	16	24	32	40	48	56	64	72	80
90	1	2	5	9	18	27	36	45	54	63	72	81	90
100	1	2	5	10	20	30	40	50	60	70	80	90	100
	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population								

Pre-breeding season

7.5.2.87 The peak razorbill population estimate within Hornsea Three and 2 km buffer during the pre-breeding season that can be apportioned to the pSPA is 42 birds. Displacement analysis for razorbill predicts mortality of less than one razorbill in the post-breeding season based on a displacement rate of 40% and a mortality rate of 2% (Table 7.21).

7.5.2.88 For immature birds, displacement analysis predicts mortality of less than one immature razorbill in the pre-breeding season based on a displacement rate of 50% and a mortality rate of 1%.

Table 7.21: Predicted razorbill mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the pre-breeding season.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	1	1	2	2	3	3	3	4	4
20	0	0	0	1	2	3	3	4	5	6	7	8	8
30	0	0	1	1	3	4	5	6	8	9	10	11	13
40	0	0	1	2	3	5	7	8	10	12	13	15	17
50	0	0	1	2	4	6	8	10	13	15	17	19	21
60	0	1	1	3	5	8	10	13	15	18	20	23	25
70	0	1	1	3	6	9	12	15	18	20	23	26	29
80	0	1	2	3	7	10	13	17	20	23	27	30	33
90	0	1	2	4	8	11	15	19	23	26	30	34	38
100	0	1	2	4	8	13	17	21	25	29	33	38	42

	Mortality rate (%)				
	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

Conclusion

7.5.2.89 There is no predicted displacement mortality of breeding adult razorbill originating from the pSPA due to Hornsea Three in any biological season. In addition, any impact on immature birds associated with FFC pSPA is likely to be negligible due to the low level of mortality predicted in all seasons. There is, therefore, no indication of an adverse effect on the razorbill breeding feature at FFC pSPA as a result of disturbance or displacement due to operation and maintenance activities from Hornsea Project Three.

Guillemot

7.5.2.90 During the breeding season, the mean foraging range of breeding guillemots is 37.8 km, while the mean-maximum range is 84.2 km and highest maximum reported 135 km (Thaxter *et al.*, 2012). According to Brown and Grice (2005) 'while birds may be found up to 150 km offshore (from breeding colonies) few bring back fish from further than 30 km distant'. That observation is consistent with the mean foraging range data presented by Thaxter *et al.*, (2012), and this strongly supports the hypothesis that common guillemots in Hornsea Three in summer (breeding season) are likely to be over-summering young immature birds rather than breeding adults from the Humberside colonies (which are over 100 km away). The RSPB FAME project has tracked breeding guillemots from Colonsay (west Scotland) and found similar results; the maximum range in 2010 and 2011 was around 80 km, with most tracks remaining within 40 km of the colony. Based on this evidence and the further information presented in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA, it is considered extremely unlikely that breeding guillemot from the colony at FFC pSPA will utilise Hornsea Three as a foraging area in the breeding season.

7.5.2.91 Guillemots in Britain and Ireland are considered to be dispersive rather than migratory (Wernham *et al.*, 2002). Breeding colonies in the UK are deserted in August, with modal departure in July (Pennington *et al.*, 2004; Brown and Grice, 2005; Forrester *et al.*, 2007). Breeding adults may desert colonies earlier than this in years when there is severe food shortage. However, such conditions have not been seen in colonies that are likely to have connectivity with Hornsea Three, with productive breeding at colonies between Humberside to south-east Scotland in recent decades.

7.5.2.92 During winter there is a slight indication from ring recovery data that birds from different parts of the UK winter in different areas (Mead, 1974). Birds from colonies in western Britain tend to winter off the west coast rather than in the North Sea. Birds from northern Britain move furthest, and include most of the recoveries in north Norway (Wernham *et al.*, 2002; see also Heubeck *et al.*, 1991). Birds from Shetland move to either Norwegian waters, the Skagerrak/Kattegat or the North Sea with immatures moving further than adults.

7.5.2.93 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the non-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of guillemot was calculated as 1,617,306 individuals. The contribution of breeding birds from FFC pSPA to this population is 4.4%.

7.5.2.94 Based on the calculations presented in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA, the following apportioning values have been applied in assessments for guillemot at Hornsea Three:

- Breeding season = N/A
- Non-breeding season = 4.4%

7.5.2.95 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015) are consistent with the approaches used in the assessments for previous offshore wind farm developments (e.g. Hornsea Project Two).

<u>Construction/decommissioning/operation</u>

Disturbance/displacement

7.5.2.96 It is assumed that displacement resulting from operational activities of Hornsea Three presents the worst case scenario with respect to overall disturbance impacts on guillemot. Therefore, the analysis of disturbance during construction/decommissioning is treated equivalently to the assessment of displacement presented below.

7.5.2.97 With regards to displacement and mortality rates that form the focus of the assessment, 50% displacement and 2-10% mortality is considered appropriately precautionary for the breeding season. For the non-breeding season, 50% displacement and 1% mortality is highlighted.

<u>Breeding season</u>

7.5.2.98 A total displacement impact of 134-669 birds is predicted in volume 2, chapter 5: Offshore Ornithology for guillemot in the breeding season using a displacement rate of 50% and a mortality rate range of 2-10%. There is considered to be no connectivity between breeding adults from FFC pSPA and Hornsea Three and as such the total displacement impact will affect immature and non-breeding birds only. Unlike breeding adult birds, immature birds are not constrained to certain areas during the breeding season and as such it is considered that the appropriate mortality rate is towards the lower end of the range presented.

7.5.2.99 Immature birds are known to visit colonies before age at first breeding (Furness, 2015), however, as Hornsea Three is located a considerable distance from any breeding colony, the immature population structure at a breeding colony may not be reflected at Hornsea Three. It is however, considered that the immature population that may occur at Hornsea Three could consist of birds from colonies around the UK, with birds likely to visit multiple colonies before age at first breeding.

7.5.2.100 It is considered likely that a large proportion of the immature population present at Hornsea Three will originate from those breeding colonies that are closest to Hornsea Three including FFC pSPA, the Farne Islands (32,855 pairs in 2016), St Abb's to Fast Castle SPA (24,258 pairs in 2016) and the Firth of Forth (21,181 pairs in 2015). These breeding colonies are smaller than FFC pSPA (41,607 pairs) however, will dilute the impact that can be apportioned to the population of immatures associated with FFC pSPA. In addition there is likely to be a proportion of the population that is associated with other breeding colonies. Therefore any apportioning of impacts from Hornsea Three to the population of immatures present at Hornsea Three would result in a negligible proportion being apportioned to FFC pSPA.

7.5.2.101 In addition to immature birds, non-breeding birds are likely to be present at Hornsea Three. Reed *et al.* (2015) indicate that at the Isle of May approximately 7% of the breeding population skip a breeding season.

<u>Non-breeding season</u>

7.5.2.102 The peak guillemot population estimate within Hornsea Three and 2 km buffer during the non-breeding season that can be apportioned to the pSPA is 784 birds. Displacement analysis for predicts mortality of four breeding adult guillemot in the non-breeding season based on a displacement rate of 50% and a mortality rate of 1% (Table 7.22).

7.5.2.103 Therefore breeding adult guillemot lost to the pSPA population as a result of displacement represent 0.005% of the pSPA breeding population (which stands at 41,607 pairs) and would result in a negligible increase in background mortality.

7.5.2.104 For immature birds, displacement analysis predicts mortality of three immature guillemot in the non-breeding season based on a displacement rate of 50% and a mortality rate of 1%.

Table 7.22: Predicted breeding adult guillemot mortality from FFC pSPA as a result of displacement from Hornsea Three and 2 km buffer during the non-breeding season.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	4	8	16	24	31	39	47	55	63	71	78
20	2	3	8	16	31	47	63	78	94	110	125	141	157
30	2	5	12	24	47	71	94	118	141	165	188	212	235
40	3	6	16	31	63	94	125	157	188	220	251	282	314
50	4	8	20	39	78	118	157	196	235	274	314	353	392
60	5	9	24	47	94	141	188	235	282	329	376	423	470
70	5	11	27	55	110	165	220	274	329	384	439	494	549
80	6	13	31	63	125	188	251	314	376	439	502	565	627
90	7	14	35	71	141	212	282	353	423	494	565	635	706
100	8	16	39	78	157	235	314	392	470	549	627	706	784

< 1% background mortality
> 1% background mortality/<1% SPA population
> 1% SPA population

Conclusion

7.5.2.105 There is predicted to be a negligible loss of breeding adult guillemot originating from the pSPA as a result of displacement from Hornsea Three in any biological season. In addition, any impact on immature birds associated with FFC pSPA is likely to be negligible due to the low level of mortality predicted in all seasons and the large BDMPS immature population to which impacts can be apportioned. There is, therefore, no indication of an adverse effect on the guillemot breeding feature at FFC pSPA as a result of disturbance or displacement due to operation and maintenance activities.

7.5.3 Coquet Island SPA

Site description

7.5.3.1 Coquet Island is located approximately 1 km of the Northumberland coast in north-east England. The island is approximately 0.07 km^2 and is located over 283 km from Hornsea Three. Coquet Island SPA was originally classified in 1985 for breeding populations of a number of seabirds (common, Arctic, roseate and Sandwich tern). An amendment in 2017 incorporated those species that formed part of the original SPA in addition to a breeding seabird assemblage consisting of 47,662 individual seabirds with the four aforementioned species, puffin and black-headed gull representing the main components of the assemblage (Natural England, 2015e). In addition there are a number of non-listed assemblage features including fulmar, herring gull, lesser black-backed gull and kittiwake.

Features screened into assessment

7.5.3.2 The screening assessment identified the potential for LSE on the following features of this pSPA:

- Fulmar (displacement in the breeding, post-breeding, non-breeding and pre-breeding seasons).

7.5.3.3 A summary of the screening process is presented in Table 7.23.

Table 7.23: Results of the screening process with respect to the Coquet Island SPA.

Feature	Project Phase	Potential Impact	Likely Significant Effect
Fulmar	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Yes
		Changes to prey availability	No

Fulmar

7.5.3.4 Fulmar is included as a non-listed assemblage feature as part of the designation for the Coquet Island SPA with a population of 125 breeding adults as detailed in the Departmental Brief for the pSPA (Natural England 2015e).

7.5.3.5 As discussed in paragraph 7.5.2.7 fulmar has an extensive foraging range meaning that Hornsea Three is within foraging range of fulmar from a number of breeding colonies. Following the approach outlined in paragraph 7.5.2.8 that makes the assumption that the contribution of a breeding colony to the population of fulmar present at Hornsea Three is related to the size of the breeding population, the proportion of fulmar present at Hornsea Three that originate from the breeding population at the Coquet Island SPA is 0.72%.

7.5.3.6 For the post-and pre-breeding seasons (autumn and spring) the BDMPS population from Furness (2015) is 957,502 individuals of which 0.009% are from the colony at Coquet Island SPA.

7.5.3.7 In the non-breeding season (winter), the BDMPS population is an estimated 568,736 individuals (Furness, 2015) of which 0.01% are from the colony at Coquet Island SPA.

7.5.3.8 Based on the above calculations, the following apportioning values will be applied in assessments for fulmar at Hornsea Three:

- Breeding season = 0.72%
- Post-breeding season = 0.009%
- Non-breeding season = 0.01%
- Pre-breeding season = 0.009%

<u>Operation/maintenance</u>

Displacement

7.5.3.9 As discussed in paragraphs 7.5.2.12 to 7.5.2.14 the appropriate displacement rate range to apply for fulmar is considered to be 10-30% in all seasons. The appropriate mortality rate to apply is considered to be 2% in the breeding season, with a 1% mortality rate in all other seasons (see paragraph 7.5.2.15).

<u>Breeding</u>

7.5.3.10 The mean-peak fulmar population estimate within Hornsea Three and 2 km buffer during the breeding season (April-August) that can be apportioned to the Coquet Island SPA is 10 birds. Displacement analysis for fulmar predicts mortality of less than one fulmar in the breeding season based on a displacement rate range of 10-30% and a mortality rate of 2% (Table 7.24). Therefore, birds lost to the population as a result of displacement would represent a negligible proportion of the pSPA population and an insignificant increase in the baseline mortality of that population.

Table 7.24: Predicted fulmar mortality from Coquet Island SPA as a result of displacement from Hornsea Three and 2 km buffer during the <u>breeding season</u>.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	0	0	1	1	1	1	1	1
20	0	0	0	0	0	1	1	1	1	1	2	2	2
30	0	0	0	0	1	1	1	2	2	2	2	3	3
40	0	0	0	0	1	1	2	2	2	3	3	4	4
50	0	0	0	1	1	2	2	3	3	4	4	5	5
60	0	0	0	1	1	2	2	3	4	4	5	5	6
70	0	0	0	1	1	2	3	4	4	5	6	6	7
80	0	0	0	1	2	2	3	4	5	6	7	7	8
90	0	0	0	1	2	3	4	5	5	6	7	8	9
100	0	0	1	1	2	3	4	5	6	7	8	9	10

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

<u>Non-breeding seasons (post-, non- and pre-breeding seasons)</u>

7.5.3.11 The mean-peak fulmar population estimate calculated for Hornsea Three and 2 km buffer during all three non-breeding seasons that can be apportioned to the Coquet Island SPA is less than one bird. As such, there is considered to be no impact on the pSPA as a result of displacement in these seasons.

<u>Conclusion</u>

7.5.3.12 Due to the negligible proportion of the SPA population affected by displacement and, the insignificant increase in background mortality it is assessed that there is no adverse effect on the integrity of the fulmar population of the Coquet Island SPA as a result of displacement mortality due to operation and maintenance activities.

7.5.4 Farne Islands SPA

Site description

7.5.4.1 The Farne Islands are a group of low-lying islands approximately 2-6 km offshore of the Northumberland coast in north-east England. The islands have a total area of approximately 1 km^2 and are located over 304 km from Hornsea Three. The Farne Islands SPA was originally classified in 1985 due to the presence of breeding populations of seabirds (common tern, Sandwich tern and Arctic tern). An amendment in 2017 incorporated those species that formed part of the original SPA alongside two additional breeding features (roseate tern and guillemot) and a breeding seabird assemblage incorporating four main components (puffin, cormorant, shag and kittiwake). In addition there are a number of non-listed assemblage features including fulmar, black-headed gull, great black-backed gull, herring gull, lesser black-backed gull and razorbill.

Features screened into assessment

7.5.4.2 The screening assessment identified the potential for LSE on the following features of this pSPA:

- Fulmar (displacement in the breeding, post-breeding, non-breeding and pre-breeding seasons).

7.5.4.3 A summary of the screening process is presented in Table 7.25.

Table 7.25: Results of the screening process with respect to the Farne Islands SPA.

Feature	Project Phase	Potential Impact	Likely Significant Effect
Fulmar	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Yes
		Changes to prey availability	No

Fulmar

7.5.4.4 Fulmar is included as a non-listed assemblage feature as part of the designation for the Farne Islands SPA with a population of 125 breeding adults as detailed in the Departmental Brief for the pSPA (Natural England, 2015f).

7.5.4.5 As discussed in paragraph 7.5.2.7 fulmar has an extensive foraging range meaning that Hornsea Three is within foraging range of fulmar from a number of breeding colonies. Following the approach outlined in paragraph 7.5.2.8 that makes the assumption that the contribution of a breeding colony to the population of fulmar present at Hornsea Three is related to the size of the breeding population, the proportion of fulmar present at Hornsea Three that originate from the breeding population at the Farne Islands SPA is 4.15%.

7.5.4.6 For the post-and pre-breeding seasons (autumn and spring) the BDMPS population from Furness (2015) is 957,502 individuals of which 0.05% are from the colony at the Farne Islands SPA.

7.5.4.7 In the non-breeding season (winter), the BDMPS population is an estimated 568,736 individuals (Furness, 2015) of which 0.06% are from the colony at the Farne Islands SPA.

7.5.4.8 Based on the above calculations, the following apportioning values will be applied in assessments for fulmar at Hornsea Three:

- Breeding season = 4.15%
- Post-breeding season = 0.05%
- Non-breeding season = 0.06%
- Pre-breeding season = 0.05%

<u>Operation/maintenance</u>

Displacement

7.5.4.9 As discussed in paragraphs 7.5.2.12 to 7.5.2.14 the appropriate displacement rate range to apply for fulmar is considered to be 10-30% in all seasons. The appropriate mortality rate to apply is considered to be 2% in the breeding season, with a 1% mortality rate in all other seasons (see paragraph 7.5.2.15).

<u>*Breeding*</u>

7.5.4.10 The mean-peak fulmar population estimate within Hornsea Three and 2 km buffer during the breeding season (April-August) that can be apportioned to the Farne Islands SPA is 59 birds. Displacement analysis for fulmar predicts mortality of less than one fulmar in the breeding season based on a displacement rate range of 10-30% and a mortality rate of 2% (Table 7.26). Therefore, birds lost to the population as a result of displacement would represent a negligible proportion of the pSPA population and an insignificant increase in the baseline mortality of that population.

Table 7.26: Predicted fulmar mortality from the Farne Islands SPA as a result of displacement from Hornsea Three and 2 km buffer during the breeding season.

Displaced (%)	Mortality rate (%)												
	1	***2***	***5***	***10***	***20***	***30***	***40***	***50***	***60***	***70***	***80***	***90***	***100***
10	0	0	0	1	1	2	2	3	4	4	5	5	6
20	0	0	1	1	2	4	5	6	7	8	9	11	12
30	0	0	1	2	4	5	7	9	11	12	14	16	18
40	0	0	1	2	5	7	9	12	14	17	19	21	24
50	0	1	1	3	6	9	12	15	18	21	24	27	30
60	0	1	2	4	7	11	14	18	21	25	28	32	35
70	0	1	2	4	8	12	17	21	25	29	33	37	41
80	0	1	2	5	9	14	19	24	28	33	38	43	47
90	1	1	3	5	11	16	21	27	32	37	43	48	53
100	1	1	3	6	12	18	24	30	35	41	47	53	59

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

<u>*Non-breeding seasons (post-, non- and pre-breeding seasons)*</u>

7.5.4.11 The mean-peak fulmar population estimate calculated for Hornsea Three and 2 km buffer during all three non-breeding seasons that can be apportioned to the Farne Islands SPA is less than one bird. As such, there is considered to be no impact on the pSPA as a result of displacement in these seasons.

<u>*Conclusion*</u>

7.5.4.12 Due to the negligible proportion of the Farne Islands SPA population affected by displacement and, the insignificant increase in background mortality it is assessed that there is no adverse effect on the integrity of the fulmar population of the Farne Islands SPA as a result of displacement mortality due to operation and maintenance activities.

7.5.5 Forth Islands SPA

Site description

7.5.5.1 The Forth Islands are located on the east coast of Scotland in and around the Firth of Forth, 384 km from Hornsea Three. The SPA consists of a number of individual islands including Inchmickery, Fidra, Lamb, Craigleith, Bass Rock, the Isle of May and a several additional smaller islands. Those islands located in the inner Firth of Forth are very low lying with those in the outer Forth steeper and rockier. The islands provide suitable nesting habitat for several seabird species and the SPA is designated for breeding populations of gannet (21,600 pairs), shag (2,400 pairs), lesser black-backed gull (1,500 pairs), Sandwich tern (440 pairs), roseate tern (8 pairs), common tern (334 pairs), Arctic tern (540 pairs) and puffin (14,000 pairs). The site regularly supports 90,000 seabirds during the breeding season, including breeding populations of fulmar (798 pairs), cormorant (200 pairs), herring gull (6,600 pairs), kittiwake (8,400 pairs), guillemot (16,000 pairs) and razorbill (1,400 pairs).

Features screened into assessment

7.5.5.2 The screening assessment identified the potential for LSE on the following features of this SPA:

- Fulmar (displacement in the breeding, post-breeding, non-breeding and pre-breeding seasons).

7.5.5.3 A summary of the screening process is presented in Table 7.27.

Table 7.27: Results of the screening process with respect to the Forth Islands SPA.

Feature	Project Phase	Potential Impact	Likely Significant Effect
Fulmar	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Yes
		Changes to prey availability	No

Fulmar

7.5.5.4 Fulmar is included as an assemblage feature as part of the designation for the Forth Islands with a population of 798 breeding pairs as detailed in the SPA citation (Scottish Natural Heritage, 2009).

7.5.5.5 As discussed in paragraph 7.5.2.7 fulmar has an extensive foraging range meaning that Hornsea Three is within foraging range of fulmar from a number of breeding colonies. Following the approach outlined in paragraph 7.5.2.8 that makes the assumption that the contribution of a breeding colony to the population of fulmar present at Hornsea Three is related to the size of the breeding population, the proportion of fulmar present at Hornsea Three that originate from the breeding population at the Forth Islands SPA is 11.5%.

7.5.5.6 For the post-and pre-breeding seasons (autumn and spring) the BDMPS population from Furness (2015) is 957,502 individuals of which 0.17% are from the colony at the Forth Islands SPA.

7.5.5.7 In the non-breeding season (winter), the BDMPS population is an estimated 568,736 individuals (Furness, 2015) of which 0.20% are from the colony at Forth Islands SPA.

7.5.5.8 Based on the above calculations, the following apportioning values will be applied in assessments for fulmar at Hornsea Three:

- Breeding season = 0.72%
- Post-breeding season = 0.17%
- Non-breeding season = 0.20%
- Pre-breeding season = 0.17%

<u>Operation/maintenance</u>

Displacement

7.5.5.9 As discussed in paragraphs 7.5.2.12 to 7.5.2.14 the appropriate displacement rate range to apply for fulmar is considered to be 10-30% in all seasons. The appropriate mortality rate to apply is considered to be 2% in the breeding season, with a 1% mortality rate in all other seasons (see paragraph 7.5.2.15).

<u>*Breeding*</u>

7.5.5.10 The mean-peak fulmar population estimate within Hornsea Three and 2 km buffer during the breeding season (April-August) that can be apportioned to the Forth Islands SPA is 164 birds. Displacement analysis for fulmar predicts mortality of up to one fulmar in the breeding season based on a displacement rate range of 10-30% and a mortality rate of 2% (Table 7.28). Therefore, birds lost to the population as a result of displacement represent 0.02-0.06% of the SPA breeding population (798 pairs) and would result in a 0.32-0.96% increase in background mortality (102 individuals).

Table 7.28: Predicted fulmar mortality from the Forth Islands SPA as a result of displacement from Hornsea Three and 2 km buffer during the breeding season.

Displaced (%)	Mortality rate (%)												
	1	*2*	*5*	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*
10	0	0	1	2	3	5	7	8	10	11	13	15	16
20	0	1	2	3	7	10	13	16	20	23	26	30	33
30	0	1	2	5	10	15	20	25	30	34	39	44	49
40	1	1	3	7	13	20	26	33	39	46	53	59	66
50	1	2	4	8	16	25	33	41	49	57	66	74	82
60	1	2	5	10	20	30	39	49	59	69	79	89	99
70	1	2	6	11	23	34	46	57	69	80	92	103	115
80	1	3	7	13	26	39	53	66	79	92	105	118	131
90	1	3	7	15	30	44	59	74	89	103	118	133	148
100	2	3	8	16	33	49	66	82	99	115	131	148	164

	< 1% background mortality		> 1% background mortality/<1% SPA population		> 1% SPA population

<u>Non-breeding seasons (post-, non- and pre-breeding seasons)</u>

7.5.5.11 The mean-peak fulmar population estimate calculated for Hornsea Three and 2 km buffer during all three non-breeding seasons that can be apportioned to the Forth Islands pSPA is two birds in the post-breeding season and one bird in the non- and pre-breeding seasons. When applying a displacement rate range of 10-30% and a mortality rate of 1%, the displacement mortality in each of these seasons is less than one bird. As such, there is considered to be no impact on the pSPA as a result of displacement in these seasons.

<u>Conclusion</u>

7.5.5.12 Due to the negligible proportion of the Forth Islands pSPA population affected by displacement and, the insignificant increase in background mortality it is assessed that there is no adverse effect on the integrity of the fulmar population of the Forth Islands pSPA as a result of displacement mortality due to operation and maintenance activities.

7.6 In-combination assessment methodology

7.6.1 Screening of other projects and plans into the in-combination assessment

7.6.1.1 The in-combination assessment considers the impact associated with Hornsea Three together with other projects and plans. The projects and plans selected as relevant to the assessments presented within this section are based upon the results of a screening exercise undertaken (see Environmental Statement volume 4, annex 5.2: Cumulative Effects Screening Matrix and volume 4, annex 5.3: Location of Schemes). Each project on the CEA long list has been considered on a case by case basis for scoping in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

7.6.1.2 In undertaking the in-combination assessment for Hornsea Three, it is important to bear in mind that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to an in-combination impact alongside Hornsea Three. For example, relevant projects and plans that are already under construction are likely to contribute to cumulative impact with Hornsea Three (providing effect or spatial pathways exist), whereas projects and plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors. For this reason, all relevant projects and plans considered in-combination alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the CEA to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each Tier in the decision-making process when considering the potential in-combination impact associated with Hornsea Three (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2). An explanation of each tier is included below:

- Tier 1: Hornsea Three considered alongside other project/plans currently under construction and/or those with a legally secure consent (i.e. projects that are not subject to an ongoing judicial review process) that have been awarded a CFD but have not yet been implemented and/or those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact;
- Tier 2: All projects/plans considered in Tier 1, as well as those project/plans that have a legally secure consent but have no CFD and/or submitted but not yet determined and/or those with a non-legally secure consent (i.e. projects that are subject to an ongoing judicial review process); and
- Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects and the adopted development plan including supplementary planning documents are the most relevant sources of information, along with information from the relevant planning authorities regarding planned major works being consulted upon, but not yet the subject of a consent application). Specifically, this Tier includes all projects where the developer has advised

PINS in writing that they intend to submit an application in the future, those projects where a Scoping Report is available and/or those projects which have published a PEIR.

7.6.1.3 The specific projects scoped into this in-combination assessment and the Tiers into which these have been allocated, are outlined in Table 7.31.

7.6.1.4 There are no projects that will act in-combination with Hornsea Three in relation to impacts that may affect the Sandwich tern feature of the Greater Wash pSPA. As such, Sandwich tern is screened out of the in-combination assessment.

7.6.2 Methodology for in-combination assessment – displacement

7.6.2.1 Predicted operational displacement effects on features of FFC pSPA associated with the array area of Hornsea Three during the operation and maintenance phase are discussed in depth in Section 7.5.2 above. No operational displacement associated with the array area of Hornsea Three are predicted for features of the Greater Wash pSPA. With respect to this in-combination assessment of displacement effects, suitable information was obtained from each relevant project's Environmental Statement chapter, Technical Report or other submitted documents.

7.6.2.2 Recently published interim guidance by JNCC *et al.* (2017) state that displacement impacts for each relevant species should be assessed based on a wide range of potential displacement and mortality rates in a 'matrix'. While some recent Environmental Statements use this matrix approach (e.g. Hornsea Project One, Aberdeen European Offshore Wind Deployment Centre, Dogger Bank Creyke Beck Projects A and B, Dogger Bank Teesside Project A and Sofia (formerly Dogger Bank Teesside B), and Seagreen Alpha and Bravo), many older projects do not. Instead of discounting data from all projects without a matrix approach, their data has been considered here where possible.

7.6.2.3 For Hornsea Three, the mean peak population estimates were calculated for Hornsea Three array area plus 2 km buffer, following JNCC *et al.* (2017). Predicted displacement mortality is not expected to occur on a year on year basis; it is considered more likely to relate to a singular event following which seabirds will respond by either redistribution or habituation.

7.6.2.4 No species where JNCC *et al.* (2017) recommend a 4 km buffer (divers and seaduck) are relevant to the assessment of the Hornsea Three array area and, none of these species were identified as VORs.

<u>Methodology</u>

7.6.2.5 In the large majority of projects that are now operational, no attempt was made to quantify either the number of birds displaced by the wind farm, or the resultant mortality levels. Instead a qualitative assessment is usually conducted and as such these projects cannot be included as part of the quantitative assessment. For certain other projects, 100% displacement has been assumed, but the resultant mortality rate is not considered and in some (e.g. Beatrice), the impact on productivity rather than mortality is considered the more appropriate metric. These projects are also excluded from the quantitative assessment.

7.6.2.6 Some applications are still within the planning process at the time of writing. It is therefore considered that the figures provided in such cases have not been finalised. The levels of mortality predicted are therefore subject to change, and so the confidence level in their results is low.

7.6.2.7 As part of the Hornsea Projects One & Two and Dogger Bank Creyke Beck A and B and Dogger Bank Teesside Projects A and Sofia (formerly Dogger Bank Teesside B) examination processes, Natural England raised concerns relating to the potential in-combination displacement of auks from projects within the North Sea. The in-combination assessment has therefore focussed on the three auk species; puffin, razorbill and guillemot. These species are amongst the most sensitive of species exposed to displacement effects and are widespread over the majority of the annual cycle in the North Sea. The impact of displacement from Hornsea Three alone has also been considered for fulmar and gannet (see Section 7.5.2). While both species are considered prone to displacement from operational wind farm areas, the consequences of displacement on these two species are considered to be trivial. They both have vast foraging areas in all seasons and have particularly high degrees of habitat flexibility (Wade *et al.*, 2016). On this basis, no quantitative in-combination displacement assessment is attempted for these two species.

7.6.2.8 Two data sources have been used to determine the potential levels of displacement and mortality from wind farms included in the in-combination assessment:

- Population data held in individual wind farm project Environmental Statements and Habitats Regulations Assessments consisting of population estimates for individual project areas rather than raw survey data; and
- Density data provided in the Natural England seabird Sensitivity Mapping for English Territorial Waters (WWT and MacArthur Green, 2013).

7.6.2.9 The latter dataset has been compiled from the JNCC's European Seabirds at Sea database from boat surveys; WWT (Consulting) Ltd.'s aerial survey database and several publically available boat based survey datasets from surveys for offshore wind farms and comprises predicted densities at a resolution of 3km x 3km grid cells.

7.6.2.10 For the data from WWT and MacArthur Green (2013), GIS has been used to derive mean densities for common guillemot, razorbill, and puffin and for individual wind farm project areas. GIS has also been used to calculate the development area plus a 2 km buffer for each wind farm project. Numbers of birds present within the footprint of each project (and project + buffer) has then been calculated through simply multiplying area (in km^2) by mean density. The Natural England data is presented for both breeding and non-breeding seasons, with no further division into a post-breeding dispersion season.

7.6.2.11 For data from individual projects, monthly population estimates have been collated where available. For some projects data is not available for the relevant buffer area and the data has been scaled up or down based on data from other project areas.

7.6.2.12 Upon obtaining mean-peak population estimates for the individual projects the numbers of birds affected through displacement and subsequent mortality has been calculated using the displacement and mortality rates outlined in Table 7.3.

7.6.2.13 For earlier Round 1 and 2 projects monthly population data is not available and it has not been possible to derive specific apportioned displacement and mortality values. For these projects a combination of both the Natural England data and available project data has been used to derive representative values. This has been undertaken by comparing known project population estimates against those from the Natural England dataset and deriving appropriate scaling factors that can then be applied to projects for which the population estimate data is lacking.

7.6.3 Methodology for in-combination assessment – collision risk

Confidence in collision risk data available from other projects

7.6.3.1 Direct comparison of the collision risks predicted by projects considered in-combination can prove problematic due to the differing assumptions made in the calculations used in the different studies, and the limited amount of species data presented in Environmental Statement chapters (Maclean *et al*., 2009). Nevertheless, a combined quantitative assessment of the in-combination impacts posed by Hornsea Three in conjunction with other projects has been undertaken, based on the information presented in other projects' supporting documentation available to date.

7.6.3.2 The in-combination assessment has been separated into seasonal mortality in order for impacts within each season to be apportioned against the relevant reference population (see Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). In-combination impacts of Hornsea Three and other relevant projects during the breeding season have been based on mean-maximum foraging range from Thaxter *et al.* (2012) (gannet) or tracking data relevant to FFC pSPA (kittiwake). However, it is also important to consider the populations of immature and non-breeding individuals that may be impacted by wind farms considered in-combination with Hornsea Three to which a proportion of collision impacts will be attributable. This has been considered in Annex 3: Phenology, connectivity and apportioning for features of FFC pSPA.

7.6.3.3 During the non-breeding period, it is assumed that individuals present from each species will originate from a wider range of colonies, with intermixing throughout the North Sea, and so the most appropriate reference populations (e.g. east coast or flyway) have been taken forward to assessment, based on literature evidence available (Furness, 2015). A greater range of projects are included, reflecting the wider movements of birds (i.e. all east coast UK wind farm projects).

<u>Collision risk modelling</u>

7.6.3.4 The earliest collision risk assessments of offshore wind farms for Round 1 and 2 projects were generally undertaken by adapting the Band (2000) collision risk model (updated in Band *et al*., 2007), developed on behalf of Scottish Natural Heritage to quantify mortality rates for birds at offshore wind farms. As flight data are collected in a fundamentally different way in the onshore and offshore environments, the boat survey data collected at these offshore sites required significant reinterpretation to become compatible with the model. This is a potential source of variability in interpretation and results between projects, particularly as a standard method of interpretation was not available at that time.

7.6.3.5 For these projects' models it was also assumed that for birds transiting through turbines at risk height, collision risk was distributed evenly within the rotor swept area (as per Option 1 or 2 of the Band model), which in the majority of cases overestimates the risk for most species which predominantly fly at lower altitudes (including some within the lower rotor swept area). As the probability of colliding with a rotor blade is lower at these lower altitudes, using the mean value instead will invariably overestimate risk, and therefore resultant mortality rates.

7.6.3.6 The most recent projects have run collision risk analyses using the Band model, updated for the offshore environment (Band, 2012; sometimes the draft version Band (2011)). The updates within Band (2012) mean that projects that have used the Band (2012) or Band (2011) models are likely to produce more realistic mortality rates than earlier projects that had to interpret the onshore Band models. This is particularly the case for those that undertook modelling using the Extended Option 3 or 4 variants.

7.6.3.7 In addition to the different models used to estimate collision mortality, different avoidance rates have been selected for impact assessment in different projects. This is the most sensitive parameter in the model, and so leads to a great deal of uncertainty in results. Mortality estimates from other projects have been converted to a common currency in this assessment consistent with those avoidance rates recommended by Cook *et al.* (2014).

7.6.3.8 A cautionary process is applied however when altering outputs (by updating prescribed avoidance rates) within projects considered within the in-combination assessment. This is particularly relevant for projects that have been consented, where values have already been accepted by decision-makers. In some other cases it is not clear in the collision modelling process, using different Band model versions, where precaution may have been built in. If this was at an earlier stage, then a higher avoidance rate may be acceptable, and so results should be converted to a "common currency", where possible as advocated by Natural England and JNCC in their Relevant Representation for Hornsea Project One and subsequent consultation for Hornsea Project Two.

Consented and as-built scenarios

7.6.3.9 As well as different models being used for different projects, some applications are still within the planning process at the time of writing, meaning that collision risk figures provided may not have been finalised. The levels of mortality predicted are therefore subject to change, and so the confidence level in their results is low. Therefore, whilst the modelling approach applied may lead to an assumption of high confidence, in reality given that the numbers used in this assessment are known to be subject to refinement (which it is understood in the majority of cases will lead to a reduction in predicted mortality numbers) the confidence in these data is low. Furthermore, it is frequently the case that projects when constructed do not reflect the maximum design scenario assessed. In many cases, the as-built scenario will represent a significantly lower impact than that assessed as the worst case for the purpose of obtaining consent.

7.6.3.10 In order to provide an appraisal of this likely over-estimation of the in-combination collision risk totals for each species, a simple analysis has been conducted comparing the turbine scenario used for collision risk modelling for projects considered in-combination with the respective as-built turbine scenario. Table 7.32 identifies the assessed, consented and as-built or planned turbine scenarios for each of the projects considered in-combination in addition to the possible change that may result if collision risk modelling were conducted utilising the as-built turbine scenario. If there is a difference between the assessed number of turbines and the consented number of turbines (i.e. those projects for which consideration in the assessment is quantitative) a simple correction factor representing the change in the number of turbines has been applied to the collision risk estimates for that project. Where differences arise between the assessed turbine scenario and the as-built/planned turbine scenario (i.e. those projects for which consideration in the assessment is qualitative) further analysis utilising the correction factors calculated by MacArthur Green (2017), has been applied in order to calculate the likely change in collision risk estimates for a project with this discussed qualitatively in the respective species sections. MacArthur Green (2017) presents an appraisal of the likely ‘headroom’ that exists in current in-combination collision risk estimates due to assessed turbine scenarios representing a higher collision risk to birds than as-built or planned turbine scenarios. The correction factors have only been applied here if the assessed turbine scenario presented in Table 7.32 matches that used by MacArthur Green (2017) (Table 7.29).

7.6.3.11 The correction factors applied in Table 5.51, Table 5.54, Table 5.56 or Table 5.58 account only for changes between assessed and consented turbine scenarios and have not been corrected using the correction factors presented in MacArthur Green (2017).

Table 7.29: Correction factors from MacArthur Green (2017) applied to collision risk estimates

Offshore wind farm	Correction factors from MacArthur Green (2017)	
	Gannet	Kittiwake
Dudgeon	0.46	
Galloper	0.43	0.42
Humber Gateway	0.50	0.39
Kentish Flats Extension	0.80	0.72
Lincs	1.01	1.04
Race Bank	0.53	0.59
Sheringham Shoal	0.97	
Teesside	0.68	0.67
Westermost Rough	0.83	0.82

Nocturnal activity factors

7.6.3.12 Appendix D of Environmental Statement volume 5, annex 5.3: Collision Risk Modelling presents a discussion on the nocturnal activity factors used for species included in collision risk modelling at Hornsea Three. Based on empirical evidence it is considered that the nocturnal activity factors that have historically been used for gannet and kittiwake in collision risk modelling (from Garthe and Hüppop, 2004) over-estimate the actual level of nocturnal activity exhibited by both gannet and kittiwake. Collision risk modelling conducted for projects considered in-combination are considered to have most certainly used the nocturnal activity factors from Garthe and Hüppop (2004) and therefore it is necessary to correct the collision risk estimates to account for this over-estimation.

7.6.3.13 The correction factor to apply to the collision risk estimates for each project considered in-combination will depend on the latitude at which a project is located. An analysis has been conducted in Appendix D of Environmental Statement volume 5, annex 5.3: Collision Risk Modelling that calculates correction factors for four geographic areas into which each of the projects considered in-combination have been assigned (Table 7.30). Two correction factors are presented, a minimum representing the minimum monthly change that can be applied cross all months and the total representing the total change in collision risk estimates in each area using a generic wind farm scenario. The ‘total’ correction factor may potentially under or over-estimate the collision risk for an individual project and therefore this is applied in the following species sections as guidance only. The application of the ‘minimum’ correction factor is considered to be precautionary as this represents the minimum change that would occur across all months.

Table 7.30: Correction factors to apply to collision risk estimates for projects in each geographic region

Geographic region	Projects within region	% change in collision risk estimates	
		Minimum	Total
East Anglia and English Channel	East Anglia One East Anglia Three Galloper Greater Gabbard Kentish Flats Extension London Array Thanet	Gannet = -10.1 Kittiwake =- 9.2	Gannet = -19.4 Kittiwake = -16.2
Southern North Sea	Blyth Demonstration Dogger Bank Creyke Beck A & B Dogger Bank Teesside A Sofia (previously Dogger Bank Teesside B) Dudgeon Hornsea Project One Hornsea Project Two Humber Gateway Lincs Race Bank Sheringham Shoal Teesside Triton Knoll Westermost Rough	Gannet = -9.3 Kittiwake = -8.5	Gannet = -19.3 Kittiwake = -16.2
Firth of Forth	Aberdeen (EOWDC) Inch Cape Kincardine Methil Neart na Gaoithe Seagreen Alpha Seagreen Bravo	Gannet = -8.4 Kittiwake = -7.8	Gannet = -19.3 Kittiwake = -16.2
Moray Firth	Beatrice Hywind Moray East	Gannet = -7.6 Kittiwake = -7.1	Gannet = -19.2 Kittiwake = -16.1

Table 7.31: List of other projects and plans considered within the in-combination assessment.

Tier	Phase	Project/Plan	Distance from Hornsea Three (km)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation and maintenance phase with Hornsea Three operation and maintenance phase
1	***Offshore wind farms***						
	Legally secure consent and awarded CfD	Aberdeen Demo	444	Up to 100MW with no more than 11 turbines	2019	No	Yes
		Hornsea Project Two	7	Up to 300 6-15MW turbines (DCO)	2018-2019	No	Yes
		Moray East	548	1116MW up to 137 turbines	Not known	Not known	Yes
		Neart na Gaoithe	372	448MW (64x7MW turbines)	After 2019	Yes	Yes
		Triton Knoll	100	Up to 288 turbines consented	2018 – 2021	No	Yes
	Under construction	Beatrice	564	588MW - 88 turbines	2017-2019	No	Yes
		Blyth Demo	258	Consented: 99MW (up to 15) In Construction: 41.5MW (5x8MW)	2019	No	Yes
		East Anglia One	152	714MW (102x7MW)	2017 – 2019	No	Yes
		Galloper	195	Up to 336MW (56x6MW turbines)	2019	No	Yes
		Hornsea Project One	7	Up to 240 5-8 MW turbines (DCO)	2017 – 2018	No	Yes
		Hywind Scotland Pilot Park	438	30MW (5x6MW turbines)	2019	No	Yes
		Race Bank	114	Up to 580MW	2017 - 2018	No	Yes
		Rampion Wind Farm	388	400MW (116x3.45MW)	2017 - 2018	No	Yes
	Operation and maintenance	Dudgeon	87	20 miles off the coast of Cromer, N North Norfolk. Up to 402 MW and 67 turbines	2015 – 2017	No	Yes
		Greater Gabbard	198	504MW (140x3.6MWturbines)	N/A	No	Yes
		Gunfleet Sands Demo	245	12MW (2x6MW)	N/A	No	Yes
		Gunfleet Sands I	240	108MW (30x3.6MW)	N/A	No	Yes
		Gunfleet Sands II	239	64.8MW (18x3.6MW)	N/A	No	Yes
		Humber Gateway	128	Up to 219MW (73x3MW turbines)	N/A	No	Yes
		Kentish Flats	272	90MW (30x3MW Vestas turbines). Fully commissioned Dec 2005	N/A	No	Yes
		Kentish Flats Extension	273	49.5MW (15x3.3MW Vestas turbines)	N/A	No	Yes
		Lincs / LID61	139	270MW (75x3.6 MW)	N/A	No	Yes
		London Array	230	630MW (175x3.6MW)	N/A	No	Yes
		Lynn and Inner Dowsing Wind Farms	147	194 MW (54x 3.6MW Siemens monopiles). Commissioned March 2009. 5km off the coast of Skegness.	N/A	No	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three (km)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation and maintenance phase with Hornsea Three operation and maintenance phase
		Methil (Samsung) Demo	412	1x7MW turbine Operated by Scottish Enterprise, round/type - Demonstration/Lease	N/A	No	Yes
		Scroby Sands	132	60MW (30x2MW turbines)	N/A	No	Yes
		Sheringham Shoal	109	316.8MW (88x3.6MW) Sheringham, Greater Wash 17-23 km off North Norfolk	N/A	No	Yes
		Teesside	224	1.5km NE Teesmouth. 62.1MW (27x2.3 MW) Commissioned July 2013.	N/A	No	Yes
		Thanet	260	300MW (100x3 MW monopile turbines) UK, offshore wind, Round 2. 12 km off Foreness Point, Kent Fully commissioned Sep 2010	N/A	No	Yes
		Westermost Rough	132	210MW (35x6MW)	N/A	No	Yes
2	***Offshore wind farms***						
	Legally secure consent and no CfD	Dogger Bank Creyke Beck A	76	Up to 1.2GW	2021 – 2024	Yes	Yes
		Dogger Bank Creyke Beck B	99	Up to 1.2GW	2021 – 2024	Yes	Yes
		Dogger Bank Teesside A	107	Up to 1.2GW	2023 - 2026	Yes	Yes
		Sofia (formerly Dogger Bank Teesside B)	95	Up to 1.2GW	2023 - 2026	Yes	Yes
		East Anglia Three	103	Up to 1200MW (up to 172 turbines of up to 7 - 12MW capacity)	2020 – 2022	Yes	Yes
		Inch Cape	384	Up to 784MW (95-110 turbines of up to 7 - 8MW capacity)	After 2019	Yes	Yes
		Kincardine Offshore Wind Farm	422	48MW (8x6MW turbines)	2019	No	Yes
		Methil Demonstration Project - 2B Energy	411	Demonstrator site	Not known	Not known	Yes
		SeaGreen Alpha	383	Up to 525MW (75x7MW)	After 2019	Yes	Yes
		Seagreen Bravo	367	Up to 525MW (75x7MW)	After 2019	Yes	Yes
	Application	Norfolk Vanguard	73	Up to 1800MW (between 120 - 257 turbines of up to 7 - 15MW capacity)	2020 – 2022	Yes	Yes
		Moray West	554	750MW Up to 90 turbines	2022-2024	Yes	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three (km)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation and maintenance phase with Hornsea Three operation and maintenance phase
	Cables						
	Application	Viking Link Interconnector	13	High voltage (up to 500 kV) Direct Current (DC) electricity interconnector	2018	No	Yes
3	**Offshore wind farms**						
		East Anglia One North	141	600 MW - 800 MW	Assumed after 2020	Yes	Yes
		East Anglia Two	158	Up to 800MW	2022 – 2024	Yes	Yes
		Norfolk Boreas	53	Up to 1800MW	Assumed after 2020	Yes	Yes
		Seagreen Charlie	366	Not known	After 2022	Yes	Yes
		Seagreen Delta	355	Not known	After 2022	Yes	Yes
		Seagreen Echo	345	Not known	After 2022	Yes	Yes
		Seagreen Foxtrot	383	Not known	After 2022	Yes	Yes
		Seagreen Golf	355	Not known	After 2022	Yes	Yes
		Thanet Extension		340 MW – 34 turbines	2021	Yes	Yes

Table 7.32: Assessed, consented and as-built/planned turbine scenarios for projects considered in-combination for collision risk impacts

Tier	Phase	Offshore wind farm	Assessed turbine scenario	Assessed capacity (MW)	Consented capacity (MW)	Consented number of turbines	As-built turbine scenario/turbine scenario currently being considered	As built/currently planned capacity	Is there a difference between the assessed turbine scenario and either the consented of as-built/planned turbine scenarios (Yes/No)?	Implications for in-combination assessment	Consideration in assessment
1	Operation and maintenance	Dudgeon	168 x 3 MW	504	560	77	67 x 6 MW	402	Yes – consented number of turbines (77) lower than that assessed (168). In addition, constructed number of turbines lower than consented	Reduction of 54% - assessed vs consented number of turbines Potential additional 6% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Greater Gabbard	140	Unavailable			140 x 3.6 MW	504	No – assessed scenario consistent with as-built scenario		
		Humber Gateway	83 x 3.6 MW	298.8	300	83	73 x 3 MW	219	Yes – as-built number of turbines (73) lower than assessed (83) however capacity of as-built turbines lower than assessed	Reduction of 12% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Kentish Flats Extension	17 x 3 MW	51			15 x 3.3 MW	49.5	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 12% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Lincs	83 x 3 MW	249	250	83	75 x 3.6 MW	270	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 10% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		London Array	271 x 3 MW	813	1000	341	175 x 3.6 MW	630	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 35% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Sheringham Shoal	108 x 3 MW	324	316.8	108	88 x 3.6 MW	316.8	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 19% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Teesside	30	Unavailable	100	30	27 x 2.3 MW	62.1	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 10% in terms of number of turbines however the assessed turbine capacity is unknown and therefore it is not known if the reduction can be applied	Qualitative
		Thanet	60 x 5 MW	300	300	-	100 x 3 MW	300	Yes – as-built scenario has more turbines than assessed scenario	As-built scenario was assessed within the ES but was not the worst case scenario. As this scenario has ultimately been built the collision risk estimates used for Thanet represent the 100 x 3 MW turbine scenario	Quantitative
		Westermost Rough	50 x 3.6 MW	180	245	80	35 x 6 MW	210	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 30% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
	Under construction	Beatrice (gannet)	142 x 7 MW	994	750	125	84 x 7 MW	588	Yes – consented number of turbines (125) lower than that assessed (142). In addition, constructed number of turbines lower than consented	Reduction of 12% - assessed vs consented number of turbines Potential additional 29% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative

Tier	Phase	Offshore wind farm	Assessed turbine scenario	Assessed capacity (MW)	Consented capacity (MW)	Consented number of turbines	As-built turbine scenario/turbine scenario currently being considered	As built/currently planned capacity	Is there a difference between the assessed turbine scenario and either the consented of as-built/planned turbine scenarios (Yes/No)?	Implications for in-combination assessment	Consideration in assessment
		Beatrice (other species)	277 x 3.6 MW	817.2	750	125	84 x 7 MW	588	Yes – consented number of turbines (125) lower than that assessed (277). In addition, constructed number of turbines lower than consented	Reduction of 55% - assessed vs consented number of turbines Potential additional 15% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Blyth Demonstration Project	15 x 8 MW	120	-	-	5 x 8 MW	40	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 67% - assessed vs consented number of turbines	Quantitative
		East Anglia One	325 x 3.6 MW	1170	1200	240	102 x 7 MW	714	Yes – consented number of turbines (240) lower than that assessed (325). In addition, project has committed to building only 102 turbines but using a different turbine scenario	Reduction of 26% - assessed vs consented number of turbines Potential additional 42% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Galloper	140 x 3.6 MW	504	504	140	56 x 6.3 MW	352.8	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 60% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Hornsea Project One	240 x 5 MW	1200	1200	-	174 x 7 MW	1218	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 28% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Hywind	5 x 6 MW	30	30	-	5 x 6 MW	30	No – assessed scenario consistent with as-built scenario		
		Race Bank	206	Unavailable	580	-	91	-	Yes - as-built scenario has fewer turbines than assessed scenario	Reduction of 56% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
	Legally secure consent and awarded CfD	Aberdeen European Offshore Wind Deployment Centre	11 x 7 MW	77	100		11 x 8.4 MW	92.4	Yes – same number of turbines, however capacity of turbines higher for as-built scenario	Potential for an minor change in collision risk due to change in turbine scenario	Qualitative
		Hornsea Project Two	300 x 5 MW	1500	1800	300	92-231	1368	Yes – planned turbine scenario has fewer turbines than assessed scenario	Reduction of 23-69% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Moray Firth Project One (MORL)	339 (139 x 3.6, 100 x 5 and 100 x 5 MW)	1500.4	1116	186	100 x 9.5 MW	950	Yes – consented number of turbines (186) lower than that assessed (339). In addition, planned turbine scenario is lower than consented	Reduction of 45% - assessed vs consented number of turbines Potential additional 25% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative

Tier	Phase	Offshore wind farm	Assessed turbine scenario	Assessed capacity (MW)	Consented capacity (MW)	Consented number of turbines	As-built turbine scenario/turbine scenario currently being considered	As built/currently planned capacity	Is there a difference between the assessed turbine scenario and either the consented of as-built/planned turbine scenarios (Yes/No)?	Implications for in-combination assessment	Consideration in assessment
		Neart na Gaoithe	128 x 3.6 MW	460.8	450	75	56 x 8 MW	450	Yes – consented number of turbines (75) lower than that assessed (128). In addition, planned turbine scenario is lower than consented	Reduction of 41% - assessed vs consented number of turbines Potential additional 15% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Triton Knoll	288 x 3.6 MW	1036.8	1200	288	90 x 9.5 MW	855	Yes – planned turbine scenario has fewer turbines than assessed scenario	Reduction of 69% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
2	Legally secure consent and no CfD	Dogger Bank Creyke Beck A and B	400 x 6 MW	2400	2400	400	-	-	No	Project was consented in 2015 and it is likely that a larger capacity turbine scenario, resulting in fewer turbines, will be constructed	-
		Dogger Bank Teesside A and Sofia (formerly Dogger Band Teesside B)	400 x 6 MW	2400	2400	400	240-400	Unavailable	No	Project was consented in 2015 and it is likely that a larger capacity turbine scenario, resulting in fewer turbines, will be constructed	-
		East Anglia Three	172 x 7 MW	1204	-	-	172 x 7 MW	1204	No		
		Inch Cape	213	Unavailable	-	-	72	Unavailable	Yes – planned turbine scenario has fewer turbines than assessed scenario	Reduction of 66% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Kincardine	8 x 6 MW	6 to 8	Up to 50 MW		7	Unavailable	Yes - planned turbine scenario has fewer turbines than assessed scenario	Reduction of 13% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Methil	1	Unavailable	-	-	2	Unavailable	Yes - planned turbine scenario has more turbines than assessed scenario	Increase of 100% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Seagreen Alpha	75 x 7 MW	525	525		35-60	525	Yes - planned turbine scenario has more turbines than assessed scenario	Reduction of 20-53% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Seagreen Bravo	75 x 7 MW	525	525		35-60	525	Yes - planned turbine scenario has more turbines than assessed scenario	Reduction of 20-53% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative

7.6.4 Maximum design scenario

7.6.4.1 The maximum design scenarios identified in Table 7.33 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The in-combination impacts presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, in order to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme. Other aspects, namely indirect impacts associated with prey redistribution and availability, pollution incidents, lighting and barrier effects are very difficult to quantify, and although it is acknowledged that in-combination impacts are possible, the magnitude of these impacts is not considered to be significant at a population level for any VOR, and is therefore not considered further within the in-combination assessment for offshore ornithology.

Table 7.33: Maximum design scenario considered for the assessment of potential in-combination impacts on offshore ornithology.

Potential impact	Maximum design scenario	Justification
Construction phase		
The impact of construction activities such as increased vessel activity and underwater noise may result in direct disturbance or displacement from important foraging and habitat areas of birds.	**Maximum design scenario: Construction vessels** Maximum design scenario as described for construction phase (see Volume 2, Chapter 5: Offshore Ornithology) assessed in-combination with the full development of the following projects: Tier 1: • Hornsea Project Two Tier 2 • Dogger Bank Creyke Beck A • Dogger Bank Creyke Beck B • Dogger Bank Teesside A • Sofia (formerly Dogger Bank Teesside B) • East Anglia Three Tier 3 Norfolk Vanguard	**Maximum design scenario: Construction vessels** Maximum design scenario provides for the greatest number of potential vessels associated with the construction phase and hence the highest likelihood of potential disturbance / displacement to bird species, as a result of multiple activities taking place over an 8 year offshore construction period. Maximum design scenario also reflects season and location with respect to a species abundance and vulnerability to an impact in the zone of influence. **Maximum design scenario: Construction activity** Maximum Design Scenario provides for the greatest disturbance/displacement effects to bird species due to construction activities (magnitude and duration).
Operation and maintenance phase		
The impact of physical displacement from an area around turbines (342) and other ancillary structures (up to twelve offshore HVAC collector substations, up to three offshore accommodation platforms and four offshore HVAC booster stations) during the operation phase of the development may result in effective habitat loss and reduction in survival or fitness rates.	Maximum design scenario as described for operation and maintenance phase assessed cumulatively with all projects in each Tier included in Table 7.31	Provides for the maximum amount (spatial extent) of habitat loss due to physical displacement effects. For sensitive species, the wind farm as a whole will be avoided, whereas for others only individual turbines will be avoided while within the wind farm. Edge-weighted layout will potentially maximise area of sea rendered unavailable to birds.
Mortality from collision with rotating turbine blades	Maximum design scenario as described for operation and maintenance phase assessed cumulatively with all projects in each Tier included in Table 7.31	Greatest rotor swept area plus parameters that maximise collision risk and therefore mortality rates for all species as the surface area available for collision increases. This is the turbine layout with the largest combined rotor swept area and collision probability, the latter at its highest when turbines are at maximum rotor speed and at the lowest tip height.
The impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of bird species.	Maximum design scenario as described for operation and maintenance phase assessed cumulatively with all projects in each Tier included in Table 7.31	Option provides for the largest possible source of direct and indirect (prey species) disturbance from noise, vessel movements and other maintenance related activity over the longest time period.

7.7 Assessment of potential effect on site integrity in-combination with other plans and projects

7.7.1 Greater Wash pSPA

Red-throated diver

<u>Construction/decommissioning</u>

Disturbance

7.7.1.1 The potential in-combination effects of the installation of the export cable for Hornsea Three have been considered together with those arising from other relevant plans and projects.

7.7.1.2 Those Tier 1 projects predicted to overlap with the construction of Hornsea Three are the Dogger Bank Zone projects (Creyke Beck A & B, Teesside A and Sofia (formerly Dogger Bank Teesside B)). Disturbance events during construction activities (including piling of foundations) may disturb and displace birds for the duration of the construction period. As construction activities will be focused at specific locations within the Hornsea Three array area, it is expected to lead to a displacement impact of lesser magnitude than that predicted during operation and maintenance. Any impacts resulting from disturbance and displacement from construction activities are considered likely to be short-term, temporary and reversible in nature, lasting only for the duration of construction activity, with birds expected to return to the area once construction activities have ceased. The construction of the offshore components of Hornsea Three will occur over a maximum duration of eight years, assuming a two phase construction scenario (Table 4.3). A gap of three years may occur between the same activity in each phase and so having the consequence that the construction period is considered to be of medium term duration (as birds may return to areas when activities are not currently occurring).

7.7.1.3 At this stage, the likely origin and routing of vessels involved in the construction of Hornsea Three or any of the Dogger projects is not known. However, for the purposes of this assessment it is considered that construction vessels involved in construction and cable laying activities associated with the Dogger Bank projects would be unlikely to originate in the Greater Wash area and are, therefore, unlikely to affect areas within the Greater Wash known to support relatively high densities of common scoter and red-throated diver. given the distance between the Dogger Bank projects and ports adjacent to the Greater Wash pSPA.

7.7.1.4 In addition to the Tier 1 projects considered above, those Tier 2 projects predicted to overlap with the construction of Hornsea Three are East Anglia Zone projects (Norfolk Vanguard and East Anglia Three).

7.7.1.5 Of these projects, it is only anticipated that the construction of Norfolk Vanguard (export cable) would potentially lead to disturbance of red-throated diver population of the Greater Wash pSPA. There is no information at this stage on the likely effects of Norfolk Vanguard, however, if it is assumed that the magnitude of the disturbance effect during construction is comparable to that predicted to arise from Hornsea Three alone, then there is no indication that there would be a significant effect on red-throated diver.

Conclusion

7.7.1.6 On the basis of the information provided above in relation the limited temporal span and localised effect installation of the export cable, combined with the relatively low densities of red-throated diver along the cable route it is assessed that there is no indication, of an adverse effect on the integrity of the red-throated diver population of the Greater Wash pSPA as a result of disturbance caused by construction and decommissioning activities in-combination with other plans and projects.

<u>In Operation/maintenance</u>

Displacement

7.7.1.7 During the operation and maintenance phase disturbance may occur as a result of vessel traffic associated with operation and maintenance activities at the array area in-combination with other operational wind farms.

7.7.1.8 Notable densities of red-throated diver are distributed throughout the Greater Wash pSPA although there are areas of lower densities located in the mouth of the Humber estuary and to the north-east of the port at Wells-next-the Sea (Lawson *et al.*, 2015).

7.7.1.9 It is anticipated that vessels involved in the operation and maintenance of wind farms located in the Greater Wash (including Lincs, Lynn, Inner Dowsing, Race Bank, Sheringham Shoal. Humber Gateway and Westermost Rough), the former Hornsea Zone and Dogger Bank will likely to transit the Greater Wash pSPA.

7.7.1.10 The area of the Greater Wash pSPA to the north of the Humber estuary is heavily transited by vessels travelling into and out of ports in the Humber estuary with two heavily used shipping routes just outside of the Greater Wash pSPA boundary. In addition, fishing activity occurs inshore of the main vessel route, with some of this activity occurring within the Greater Wash pSPA boundary. Closer to the Humber estuary, in the area in which the Humber Gateway offshore wind farm is located, the level of vessel activity is even higher due to vessels transiting into and out of the Humber estuary. The area of the Greater Wash pSPA to the south of the Humber estuary is heavily used by vessels that are travelling either to ports in the Humber estuary, ports in the Wash or further south using existing shipping routes.

7.7.1.11 It is anticipated that vessel movements associated with operation and maintenance of offshore wind farms will largely occur within areas that are already substantially utilised by vessels. Any disturbance impacts associated with vessel movements to and from these projects are considered to represent a negligible increase in current baseline levels of disturbance.

Conclusion

7.7.1.12 It is assessed that there is no indication of an adverse effect on the integrity of the red-throated diver population of the Greater Wash pSPA as a result of disturbance due to operation and maintenance activities in-combination with other plans and projects.

Common scoter

Construction/decommissioning

Disturbance

7.7.1.13 The potential in-combination effects of the installation of the export cable for Hornsea Three have been considered together with those arising from other relevant plans and projects.

7.7.1.14 Those Tier 1 projects predicted to overlap with the construction of Hornsea Three are the Dogger Bank Zone projects (Creyke Beck A & B, Teesside A and Sofia (formerly Dogger Bank Teesside B)). Disturbance events during construction activities (including piling of foundations) will disturb and displace birds for the duration of the construction period. As construction activities will be focused at specific locations within the Hornsea Three array area, it is expected to lead to a displacement impact of lesser magnitude than that predicted during operation and maintenance. Any impacts resulting from disturbance and displacement from construction activities are considered likely to be short-term, temporary and reversible in nature, lasting only for the duration of construction activity, with birds expected to return to the area once construction activities have ceased. The construction of the offshore components of Hornsea Three will occur over a maximum duration of eight years, assuming a two phase construction scenario (Table 4.3). A gap of three years may occur between the same activity in each phase and so having the consequence that the construction period is considered to be of medium term duration (as birds may return to areas when activities are not currently occurring).

7.7.1.15 At this stage, the likely origin and routing of vessels involved in the construction of Hornsea Three or any of the Dogger Bank projects is not known. However, for the purposes of this assessment it is considered that construction vessels involved in construction and cable laying activities associated with the Dogger Bank projects would be unlikely to originate in the Greater Wash area and are, therefore, unlikely to affect areas within the Greater Wash known to support relatively high densities of common scoter and red-throated diver. given the distance between the Dogger Bank projects and ports adjacent to the Greater Wash pSPA.

7.7.1.16 In addition to the Tier 1 projects considered above, those Tier 2 projects predicted to overlap with the construction of Hornsea Three are East Anglia Zone projects (Norfolk Vanguard and East Anglia Three).

7.7.1.17 Of these projects, it is only anticipated that the construction of Norfolk Vanguard (export cable) would potentially lead to disturbance of the common scoter population of the Greater Wash pSPA. There is no information at this stage on the likely effects of Norfolk Vanguard, however, if it is assumed that the magnitude of the disturbance effect during construction is comparable to that predicted to arise from Hornsea Three alone, then there is no indication that there would be a significant effect on common scoter.

Conclusion

7.7.1.18 On the basis of the information localised effect installations of the export cable, combined with the extremely low level of interaction between the export cable route and areas of common scoter density it is assessed that there is no indication of an adverse effect on the integrity of the common scoter population of the Greater Wash pSPA as a result of disturbance due to construction and decommissioning activities in-combination with other plans and projects.

Operation/maintenance

Displacement

7.7.1.19 During the operation and maintenance phase disturbance may occur as a result of vessel traffic associated with operation and maintenance activities at the array area in-combination with other operational wind farms.

7.7.1.20 Lawson *et al.* (2015) demonstrated that the distribution of common scoter in the Greater Wash Area of Search is limited and consistently restricted to specific areas, particularly around the mouth of The Wash.

7.7.1.21 It is anticipated that vessels involved in the operation and maintenance of wind farms located in the Greater Wash (including Lincs, Lynn, Inner Dowsing, Race Bank, Sheringham Shoal. Humber Gateway and Westermost Rough), the former Hornsea Zone and Dogger Bank will be likely to transit the Greater Wash pSPA.

7.7.1.22 The area of the Greater Wash pSPA to the north of the Humber estuary is heavily transited by vessels travelling into and out of ports in the Humber estuary with two heavily used shipping routes just outside of the Greater Wash pSPA boundary. In addition, fishing activity occurs inshore of the main vessel route, with some of this activity occurring within the Greater Wash pSPA boundary. Closer to the Humber estuary, in the area in which the Humber Gateway offshore wind farm is located, the level of vessel activity is even higher due to vessels transiting into and out of the Humber estuary. The area of the Greater Wash pSPA to the south of the Humber estuary is heavily used by vessels that are travelling either to ports in the Humber estuary, ports in the Wash or further south using existing shipping routes.

7.7.1.23 It is anticipated that vessel movements associated with operation and maintenance of offshore wind farms will largely occur within areas that are already substantially utilised by vessels. Any disturbance impacts associated with vessel movements to and from these projects are considered to represent a negligible increase in current baseline levels of disturbance.

Conclusion

7.7.1.24 It is assessed that there is no indication, of an adverse effect on the integrity of the common scoter population of the Greater Wash pSPA as a result of displacement due to operation and maintenance activities in-combination with other plans and projects.

7.7.2 FFC pSPA/ Flamborough Head and Bempton Cliffs SPA

Fulmar

Operation/maintenance

Displacement

7.7.2.1 There is little quantitative information on the potential displacement of fulmar from other wind farm projects that may act in-combination with Hornsea Three. However, Hornsea Three is unlikely to contribute a significant amount of additional mortality relative to the amount that may already occur at projects that may act in-combination. For example, at Hornsea Three displacement mortality in the breeding season is up to two birds with less than one bird estimated for the post-, non- and pre-breeding seasons.

Conclusion

7.7.2.2 The displacement mortality predicted for Hornsea Three is considered unlikely to materially alter the current in-combination displacement impact for fulmar at FFC pSPA. On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three, this will result in an adverse effect on the site integrity of FFC pSPA.

Gannet

Operation/maintenance

Collision risk

7.7.2.3 A mean-maximum foraging range of 229 km has been used to determine which projects are included within the in-combination assessment during the breeding season. For those projects within mean-maximum foraging range a precautionary assumption that 100% of birds within the project sites originate from the pSPA during the breeding season has been applied with the exception of the three Hornsea projects and all four Dogger Bank projects. The precaution identified when applying this assumption relates to the likely population structure of gannets in the southern North Sea – no population will comprise solely of breeding adults with immature birds known to return to natal waters throughout the breeding season (Nelson, 2002).

7.7.2.4 For the three Hornsea projects the apportioning value calculated for the breeding season is used following the approach used at Hornsea Project Two. For the Dogger Bank projects it has been assumed that 50% of birds present within the project site are adult birds from that pSPA (although note that this proportion does not include consideration of immature and non-breeding birds and is therefore very precautionary). It should be noted that the use of these apportioning values for the respective projects was agreed with Natural England during the respective examination periods of these projects with these values also forming part of the consent decision by the Secretary of State.

7.7.2.5 Table 7.36 presents collision risk estimates sourced for all projects considered in-combination across all biological seasons relevant for gannet. Where available, collision risk estimates are presented based on the Extended model of Band (2012). Seasonal collision risk estimates are provided along with seasonal apportioning values and the resulting collision estimates apportioned to the pSPA.

7.7.2.6 For Tier 1 projects, a total in-combination collision risk mortality of 119 gannets is apportioned to the pSPA across a full annual cycle with Hornsea Three contributing 2.9% of this total. This level of in-combination mortality represents 0.7% of the pSPA population (8,469 pairs) and an 8.8% increase in baseline mortality (1,372 individuals). When Tier 2 projects are included, the in-combination collision risk mortality is 193, which represents 1.14% of the pSPA population and a 14.1% increase in baseline mortality.

7.7.2.7 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 7.34), the total in-combination collision risk estimate for Tier 1 reduces by 5%. When all tiers are considered the reduction is 19.3%. In addition, there are likely to be considerable reductions to the collision risk estimates calculated for Hornsea Project Two as this project is currently planning to deploy a turbine scenario that will meet the consented maximum project capacity but using fewer higher capacity turbines (Table 7.34). Reductions in collision risk estimates are also likely for Triton Knoll as this project is currently planning a turbine scenario that is below the consented maximum capacity for the project. Based on the changes that have occurred between assessment and construction for those projects in Tier 1, it is considered highly likely that the eventual as-built turbine scenarios for Tier 2 projects such as Dogger Bank Creyke Beck A&B and those projects located in the Firth of Forth will contain fewer higher capacity turbines that will lead to reductions in the collision risk estimates incorporated into this in-combination assessment.

Table 7.34: Changes to collision risk estimates for gannet calculated when applying the turbine scenario correction factors from MacArthur Green (2017)

Offshore wind farm	Breeding season		Post-breeding season		Pre-breeding season		Annual	
	No correction	Corrected	No correction	Corrected	No correction	Corrected	No correction	Corrected
Dudgeon[9]	10	10	1	1	1	1	12	12
Galloper			1	1	1	0	2	1
Humber Gateway	2	1	0	0	1	0	2	1
Kentish Flats Extension			0	0	0	0	0	0
Lincs	2	2	0	0	0	0	2	2
Race Bank	34	18	1	0	0	0	35	18
Sheringham Shoal	14	14	0	0	0	0	14	14
Teesside	5	3	0	0	0	0	5	3
Westermost Rough	0	0	0	0	0	0	0	0
Tier 1								
Other Tier 1 projects	11		12		8		31	
Total	94	59	15	14	10	10	119	82
% change	37.5		7.2		5.5		50.3	
Tier 2								
Other Tier 1 and 2 projects	76		27		18		121	
Total	142	124	30	29	20	19	193	173
% change	13.0		3.6		2.8		19.3	

7.7.2.8 The collision risk estimates presented in Table 7.34 have also been corrected to account for the over-estimation of nocturnal flight activity (Table 7.35) by applying the nocturnal activity correction factors presented in Table 7.30. When applying the 'minimum' correction factor the total number of collisions for Tier 1 projects reduces by 9.3%. When all tiers are considered the reduction is 9.2%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 7.35 when applying the 'total' correction factor.

Table 7.35: Correction to collision risk estimates for gannet to take account of the over-estimation of nocturnal flight activity

Season	Tier	Uncorrected collision risk estimate	Corrected collision risk estimate	
			Minimum	Total
Breeding	1	94	85	76
	1 and 2	142	129	115
Post-breeding	1	15	14	12
	1 and 2	30	28	25
Pre-breeding	1	10	9	8
	1 and 2	20	18	16
Total	1	119	108	96
	1 and 2	193	175	156

[9] The correction factor from MacArthur Green (2017) for Dudgeon has been applied to collision risk estimate calculated using the assessed turbine scenario and not the collision risk estimate presented in Table 7.36 which accounts for the reduction between the assessed and consented turbine scenario

Conclusion

7.7.2.9 Hornsea Three contributes to less than 3% of the in-combination collision risk total for gannet at FFC pSPA. PVA modelling (MacArthur Green, 2015) indicates that the resulting levels of in-combination mortality predicted to arise (Table 7.36) would not be sufficient for the population to decline below the FFC pSPA citation for this species. This level of in-combination mortality does not include consideration of as-built scenarios (Table 7.34) or nocturnal activity factors (Table 7.35) which, if taken into account, would further reduce the in-combination collision risk.

7.7.2.10 The population of gannet at the pSPA has increased considerably in recent years. The observed rate of increase in the number of gannet at Bempton has averaged approximately 9.9% between 1985 and 2017 and approximately 9.4% between 2000 and 2017. The maximum predicted growth rate for this species is 9.9%, calculated using the method proposed by Niel & Lebreton (2005). Therefore, the population appears to have grown at a rate similar to the predicted maximum. Previous modelling has suggested that the population has undergone considerable net immigration which has permitted the observed rate of growth (MacArthur Green, 2015).

7.7.2.11 PVA modelling for the FFC pSPA population of gannet has previously been conducted as part of the assessments presented for the Hornsea Project Two offshore wind farm (MacArthur Green, 2015). Those models assumed a project life time of 25 years whereas the operational life of Hornsea Three is expected to be 35 years. Two outputs from that PVA modelling are considered in this assessment: change in median population growth rate and counterfactual of population size (M. Trinder pers. comm.) and so the changes predicted in growth rate over 25 years are appropriate for inference here without any need for correction. In contrast, estimates of the counterfactual of population size, are dependent on the period over which they are calculated. However it is possible to obtain an approximate prediction for the output at 35 years through extrapolation of the values obtained after 5, 10, 15, 20 and 25 years (M. Trinder pers. comm.). This approach can be used for both the density independent and density dependent versions of the model, although the nonlinearity of the density dependent predictions reduces the degree of confidence which can be placed in this approach. However, this version of the model predicts changes of lower magnitude to those predicted by the density independent version of the model and this relative difference is expected to remain even at 35 years. The difference in predictions at 25 years is included here for reference to highlight the conservatism of the density independent model.

7.7.2.12 PVA modelling (MacArthur Green, 2015) predicts a conservative growth rate of 1.79% (density independent and excluding any immigration). If additional mortality of 125 birds annum is assumed (the closest modelled output to the predicted in-combination total for Tier 1 projects) then the model predicts a slight reduction in growth rate of 0.56%. Under this scenario, the predicted median impacted population size after 25 years would be approximately 87% (and when extrapolated to 35 years, approximately 82%) of that which the model predicts would occur in the in the absence of any additional impact from Hornsea Three in-combination. This is a relative reduction in population size (compared to that which might otherwise have arisen). The model predicts a positive growth rate, and so the impacted population after 35 years would still be larger than that which was assumed for the initiation of the modelling exercise (i.e. the designated population at the pSPA).

7.7.2.13 If additional mortality of 200 birds per annum is assumed (the closest modelled output to the predicted in-combination total for Tier 1 and 2 projects) then the model predicts a slight reduction in growth rate of 0.91%. Under this scenario, the predicted median impacted population size after 25 years would be approximately 81% (and when extrapolated to 35 years, approximately 71%) of that which the model predicts would occur in the in the absence of any additional impact from Hornsea Three in-combination. As for Tier 1 projects the impacted population after 35 years would still be larger than that which was assumed for the initiation of the modelling exercise. A density dependent model was also run. This model predicts a lesser change in growth rate, approximately 0.6% and consequently a higher ratio of impacted to unimpacted median population size after 25 years (approximately 85-86%).

7.7.2.14 The change in population growth rate as a result of the impacts predicted for Tier 1 project and for Tier 1 and 2 projects combined is unaffected by the project lifetime and therefore the population of gannet at FFC pSPA is still expected to grow.

7.7.2.15 The current population at the pSPA (26,784 individuals) is approximately 58% higher than the cited population and the population has increased 240% since the 2004 gannet census (Wanless *et al.,* 2005). PVA modelling predicts (without any density-dependence taken into account which almost certainly operate) that the population of gannet at FFC pSPA would still continue to increase however, over the lifetime of Hornsea Three the resultant population would be 18-29% lower than the population that would occur without the presence of Tier 1 projects. Therefore there is no indication that additional mortality from Hornsea Three alone or in-combination would result in the population declining below the cited population.

7.7.2.16 On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three in-combination with other projects, that the population is likely to decline, over a period of 35 years, to an extent that would mean that the breeding gannet population of the FFC pSPA would no longer be considered to be in favourable condition.

Table 7.36: Predicted in-combination collision mortality for gannet[10]

Project	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding season			Post-breeding			Pre-breeding		
					No. of collisions	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*
Hornsea Project Three	Band (2012)	3	98	15	7	40	3	5	4.8	0	3	6.2	0
Tier 1													
Aberdeen European Offshore Wind Deployment Centre	Band (2012)	2	98.9	9				5	4.8	0	0	6.2	0
Beatrice	Band (2012)	3	98	37				19	4.8	1	4	6.2	0
Blyth Demonstration Project	Band *et al.* (2007)	1	98.9	8	4	100	4	2	4.8	0	3	6.2	0
Dudgeon	Band (2000)	1	98.9	37	10	100	10	18	4.8	1	9	6.2	1
East Anglia One	Band (2012)	3	98	68				63	4.8	3	3	6.2	0
Galloper	Band *et al.* (2007)	1	98.9	56				28	4.8	1	11	6.2	1
Greater Gabbard	Band (2000)	1	98.9	28				8	4.8	0	9	6.2	1
Hornsea Project One	Band (2012)	4	98	4	1	72	0	2	4.8	0	1	6.2	0
Hornsea Project Two	Band (2012)	4	98	18	5	72	4	9	4.8	0	4	6.2	0
Humber Gateway	Not available	1	98.9	4	2	100	2	1	4.8	0	1	6.2	0
Hywind	Band (2011/12)	1	98.9	7				2	4.8	0	2	6.2	0
Kentish Flats Extension	Band (2012)	1	98.9	0				0	4.8	0	0	6.2	0
Lincs	Band (2000)	1	98.9	5	2	100	2	1	4.8	0	2	6.2	0
London Array	Band (2000)	1	98.9	6				2	4.8	0	0	6.2	0
Moray Firth Project One (MORL)	Band (2012)	3	98	16				5	4.8	0	1	6.2	0
Neart na Gaoithe	Band (2012)	1	98.9	334				57	4.8	3	64	6.2	4

[10] Grey shading represents projects which fall outside of foraging range from SPA colonies and therefore no data is considered in the breeding season.

Project	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding season			Post-breeding			Pre-breeding		
					No. of collisions	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*
Race Bank	Band (2000)	1	98.9	50	34	100	34	12	4.8	1	4	6.2	0
Sheringham Shoal	Band (2000)	1	98.9	18	14	100	14	3	4.8	0	0	6.2	0
Teesside	Band (2000)	1	98.9	7	5	100	5	2	4.8	0	0	6.2	0
Thanet	Band (2000)	1	98.9	1				0	4.8	0	0	6.2	0
Triton Knoll	Band (2000)	1	98.9	122	17	100	17	65	4.8	3	40	6.2	2
Westermost Rough	Band *et al.* (2007)	1	98.9	0	0	100	0	0	4.8	0	0	6.2	0
Tier 1 total							**94**			**15**			**10**
Tier 2													
Dogger Bank Creyke Beck A and B	Band (2012)	3	98	121	41	50	20	48	4.8	2	32	6.2	2
Dogger Bank Teesside A and B[11]	Band (2012)	3	98	136	56	50	28	39	4.8	2	41	6.2	3
East Anglia Three	Band (2012)	3	98	48				33	4.8	2	10	6.2	1
Inch Cape	Band (2012)	1	98.9	365				29	4.8	1	5	6.2	0
Kincardine	Band (2012)	3	98	30				13	4.8	1	0	6.2	0
Methil	Band (2011/12)	Unknown	98.9	1				0	4.8	0	0	6.2	0
Seagreen Alpha	Band (2012)	3	98	494				91	4.8	4	33	6.2	2
Seagreen Bravo	Band (2012)	3	98	332				64	4.8	3	37	6.2	2
Tier 2 total							**48**			**15**			**10**
Overall total							**142**			**30**			**20**

[11] Dogger Bank Teesside B is now called Sofia Offshore Wind Farm

Operation/maintenance

Displacement

7.7.2.17 There is little quantitative information on the potential displacement of gannet from other wind farm projects that may act in-combination with Hornsea Three. The assessment undertaken for Hornsea Project Two considered the available information and concluded that quantitative assessments are available for four projects: Hornsea Project One, Hornsea Project Two, Dogger Bank Creyke Beck A & B, and Sofia (formerly Dogger Bank Teesside B). The total displacement mortality associated with these projects is 15 gannets based on the displacement and mortality rates applied in the assessments for each project.

7.7.2.18 There is no additional information available for in-combination effects and so the combined predicted mortality of Hornsea Three (8 individuals) together with Hornsea Project One, Hornsea Project Two, Dogger Bank Creyke Beck A & B, Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B) is assumed to be 23 gannets.

7.7.2.19 This represents 0.14% of the FFC pSPA population (8,469 pairs) and results in an increase in background mortality (1,372 individuals) of 1.68%.

Conclusion

7.7.2.20 An in-combination displacement impact of 14 birds would not adversely effect the site integrity of FFC pSPA. PVA modelling (MacArthur Green, 2015) indicates that the resulting levels of in-combination mortality predicted to arise would not be sufficient for the population to decline below the FFC pSPA citation for this species.

7.7.2.21 Based on a modelled impact of 25 gannet (the closest modelled impact to the in-combination displacement total) the median growth rate would be expected to decline by 0.09-0.11% (density independent PVA model excluding any immigration). The resulting population of gannet at FFC pSPA after 25 years would therefore be expected to represent 97.5% (and when extrapolated to 35 years, approximately 97%) of the population that would occur without the presence of Hornsea Three.

7.7.2.22 A density dependent model was also run, with this predicting a lesser change in growth rate, approximately 0.07% and consequently a higher ratio of impacted to unimpacted median population size after 25 years (approximately 98%).

7.7.2.23 The current population at the pSPA (26,784 individuals) is approximately 58% higher than the cited population and the population has increased 240% since the 2004 gannet census (Wanless *et al.,* 2005). PVA modelling predicts that the population of gannet at FFC pSPA would still continue to increase however, over the lifetime of Hornsea Three the resultant population would be 2.5% lower than the population that would occur without the presence of Tier 1 projects. Therefore there is no indication that additional mortality from Hornsea Three alone or in-combination would result in the population declining below the cited population.

7.7.2.24 On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three in-combination with other projects, that the population is likely to decline, over a period of 35 years, to an extent that would mean that the breeding gannet population of the FFC pSPA would no longer be considered to be in favourable condition.

Kittiwake

Operation/maintenance

Collision risk

7.7.2.25 During the breeding season, a foraging range approach has been used to identify those plans and projects that may have connectivity with the FFC pSPA. Based on FAME tracking data a mean-maximum foraging range of 156 km has been used (as derived by Natural England (Natural England, 2015d)). However, it is important to note that this is the maximum mean-maximum foraging range with considerable variability between years (e.g. using tracking data from 2011 yields a mean-maximum foraging range of 58 km). For projects within foraging range, project-specific apportioning values have been used where available. This therefore applies to Hornsea Project One, Hornsea Project Two and Dogger Bank Creyke Beck A&B. The apportioning approach used for assessments at the Dogger Bank Creyke Beck projects has been updated as part of the assessments undertaken for East Anglia Three, which utilised contemporaneous population data (from Furness, 2015) instead of updated population data for FFC pSPA. As such, the apportioning value used for Dogger Bank Creyke Beck A&B has been updated to reflect the updated apportioning value calculated in the assessments for East Anglia Three.

7.7.2.26 Table 7.37 presents collision risk estimates sourced for all projects considered in-combination across all biological seasons relevant for kittiwake. Where available, collision risk estimates are presented based on the Extended model of Band (2012). Seasonal collision risk estimates are provided along with seasonal apportioning values and the resulting collision estimates apportioned to the pSPA.

7.7.2.27 For Tier 1 projects, a total in-combination collision risk mortality of 58 kittiwake is apportioned to the pSPA across a full annual cycle that are. This represents 0.07% of the pSPA population (44,520 pairs) and a 0.45% increase in baseline mortality (13,000 individuals). When Tier 2 projects are included, the in-combination collision risk mortality is 119, which represents 0.13% of the pSPA population and a 0.92% increase in baseline mortality.

7.7.2.28 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 7.29), the total in-combination collision risk estimate for Tier 1 reduces by 7.1%. When all tiers are considered the reduction is 3.4%. In addition, there are likely to be considerable reductions to the collision risk estimates calculated for Hornsea Project Two as this projects is currently planning to deploy a turbine scenario that will meet the consented maximum project capacity but using fewer higher capacity turbines (Table 7.32). Reductions in collision risk estimates are also likely for Triton Knoll as this project is currently planning a turbine scenario that is below the consented maximum capacity for the project. Based on the changes that have occurred between assessment and construction for those projects in Tier 1, it is considered highly likely that the eventual as-built turbine scenarios for Tier 2 projects such as Dogger Bank Creyke Beck A&B and those projects located in the Firth of Forth will contain fewer higher capacity turbines that will lead to reductions in the collision risk estimates incorporated into this in-combination assessment.

Table 7.37: Changes to collision risk estimates for kittiwake calculated when applying the turbine scenario correction factors from MacArthur Green (2017)

Offshore wind farm	Breeding season		Post-breeding season		Pre-breeding season		Annual	
	No correction	Corrected	No correction	Corrected	No correction	Corrected	No correction	Corrected
Galloper			1	0	1	1	3	1
Humber Gateway	2	1	0	0	0	0	2	1
Kentish Flats Extension			0	0	0	0	0	0
Lincs	1	1	0	0	0	0	1	1
Race Bank	1	1	1	1	0	0	3	2
Teesside			1	1	0	0	1	1
Westermost Rough	0	0	0	0	0	0	0	0
Tier 1								
Other Tier 1 projects	32		9		8		49	
Total	35	34	13	11	10	9	58	54
% change	4.5		11.3		10.9		7.1	
Tiers 1 and 2								
Other Tier 1 and 2 projects	46		33		30		110	
Total	50	49	37	35	32	31	119	115
% change	3.2		3.9		3.3		3.4	

7.7.2.29 The collision risk estimates presented in Table 7.39 have also been corrected to account for the over-estimation of nocturnal flight activity (Table 7.38) by applying the nocturnal activity correction factors presented in Table 7.30. When applying the 'minimum' correction factor the total number of collisions for Tier 1 projects reduces by 8.5%. When all tiers are considered the reduction is 8.4%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 7.38 when applying the 'total' correction factor.

Table 7.38: Correction to collision risk estimates for kittiwake to take account of the over-estimation of nocturnal flight activity

Season	Tier	Uncorrected collision risk estimate	Corrected collision risk estimate	
			Minimum	Total
Breeding	1	35	32	30
	1 and 2	50	46	42
Post-breeding	1	13	12	11
	1 and 2	37	34	31
Pre-breeding	1	10	9	8
	1 and 2	32	29	27
Total	1	58	53	48
	1 and 2	119	109	100

Conclusion

7.7.2.30 PVA modelling (MacArthur Green, 2015) indicates that the resulting levels of in-combination mortality predicted to arise (Table 7.39) would not be sufficient for the population to decline below the FFC pSPA citation for this species. This level of in-combination mortality does not include consideration of as-built scenarios (Table 7.37) or nocturnal activity factors (Table 7.38) which, if taken into account, would further reduce the in-combination collision risk.

7.7.2.31 There is some uncertainty about how the kittiwake population that is designated as part of the FFC pSPA has changed since the 1970s (http://jncc.defra.gov.uk/page-2889) and it has been argued that the population may have been somewhat higher than it is now (see submissions during the Hornsea Project One and Hornsea Project Two examinations and critique of these counts provided in Coulson (2011)). However, since the Seabird 2000 census the number of kittiwake at the pSPA has increased by 7.8% (JNCC, 2017c). It has, however, been assumed for the purposes of modelling that the population has recently been relatively stable.

7.7.2.32 PVA modelling for the FFC pSPA population of kittiwake has previously been conducted as part of the assessments presented for the Hornsea Project Two offshore wind farm (MacArthur Green, 2015). Those models assumed a project life time of 25 years whereas the operational life of Hornsea Three is expected to be 35 years. Two outputs from that PVA modelling are considered in this assessment: change in median population growth rate and counterfactual of population size (M. Trinder pers. comm.) and so the changes predicted in growth rate over 25 years are appropriate for inference here without any need for correction. In contrast, estimates of the counterfactual of population size, are dependent on the period over which they are calculated. However it is possible to obtain an approximate prediction for the output at 35 years through extrapolation of the values obtained after 5, 10, 15, 20 and 25 years (M. Trinder pers. comm.). This approach can be used for both the density independent and density dependent versions of the model, although the nonlinearity of the density dependent predictions reduces the degree of confidence which can be placed in this approach. However, this version of the model predicts changes of lower magnitude to those predicted by the density independent version of the model and this relative difference is expected to remain even at 35 years. The difference in predictions at 25 years are included here for reference to highlight the conservatism of the density independent model.

7.7.2.33 A maximum growth rate of 13.3% has been calculated for kittiwake (following Niel and Lebreton, 2005), but PVA modelling (MacArthur Green, 2015) predicts a conservative growth rate of 3.9% (density independent and excluding any immigration). If additional mortality of 100 birds per annum is assumed (the closest modelled output to the predicted in-combination total for Tier 1 projects) then the model predicts a very slight reduction of 0.13 – 0.17%. Under this scenario, the predicted median impacted population size after 25 years would be approximately 97-98% (and when extrapolated to 35 years, approximately 97%) of that which the model predicts would occur in the in the absence of any additional impact from Hornsea Three. This is a relative reduction in population size (compared to that which might otherwise have arisen). The model predicts a positive growth rate, and so the impacted population after 35 years would still be larger than that which was assumed for the initiation of the modelling exercise.

7.7.2.34 If additional mortality of 150 birds per annum is assumed (the closest modelled output to the predicted in-combination total for Tier 1 and 2 projects) then the model predicts a very slight reduction of 0.16 – 0.19%. Under this scenario, the predicted median impacted population size after 25 years would be approximately 96% (and when extrapolated to 35 years, approximately 95%) of that which the model predicts would occur in the in the absence of any additional impact from Hornsea Three. As for Tier 1 projects the impacted population after 35 years would still be larger than that which was assumed for the initiation of the modelling exercise

7.7.2.35 The change in population growth rate as a result of the impacts predicted for Tier 1 project and for Tier 1 and 2 projects combined is unaffected by the project lifetime and therefore the population of kittiwake at FFC pSPA is still expected to grow.

7.7.2.36 MacArthur Green (2015) argues that it is likely that the population has remained around 40,000 pairs because strong competition for resources may be limiting colony size through density-dependence (Jovani *et al*. 2012). A density dependent model was, therefore, also run and this model predicts a very small change in growth rate, approximately 0.03 – 0.06% and consequently a considerably higher ratio of impacted to unimpacted median population size after 25 years (approximately 98-99%).

7.7.2.37 The current population at the pSPA is 13% higher than the cited population and for those years for which complete colony counts exist the population has increased 7.8% since the Seabird 2000. Recent years suggest a positive growth rate (e.g. 2.1% between 2008 and 2017 and 1.0% between 2016 and 2017, although note that this is only two years). PVA modelling predicts (without any density-dependence taken into account which almost certainly operate) that the population of kittiwake at FFC pSPA would still continue to increase however, over the lifetime of Hornsea Three the resultant population would be 3-5% lower than the population that would occur without the presence of additional in-combination mortality. Therefore there is no indication that additional mortality from Hornsea Three alone or in-combination would result in the population declining below the cited population.

7.7.2.38 On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three in-combination with other projects, the population is likely to decline, over a period of 35 years, to an extent that would mean that the breeding kittiwake population of the FFC pSPA would no longer be considered to be in favourable condition.

Table 7.39: Predicted in-combination collision mortality for kittiwake[12].

Project	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding season			Post-breeding			Pre-breeding		
					No. of collisions	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*
Hornsea Project Three	Band (2012)	3	98	82	42	40.4	18	26	5.4	1	14	7.1	1
Tier 1													
Aberdeen European Offshore Wind Deployment Centre	Band (2012)	2	99.2	14				4	5.4	0	0	7.1	0
Beatrice	Band (2012)	3	98	20				2	5.4	0	2	7.1	0
Blyth Demonstration Project	Band (2011)	1	99.2	4				2	5.4	0	1	7.1	0
Dudgeon	Band (2000)	Not available	99.2	0	0	100	0	0	5.4	0	0	7.1	0
East Anglia One	Band (2012)	3	98	24				17	5.4	1	6	7.1	0
Galloper	Band *et al.* (2007)	1	99.2	48				20	5.4	1	20	7.1	1
Greater Gabbard	Band (2000)	1	99.2	20				5	5.4	0	13	7.1	1
Hornsea Project One	Band (2012)	4	98	2	1	83	1	1	5.4	0	0	7.1	0
Hornsea Project Two	Band (2012)	4	98	4	2	83	2	1	5.4	0	0	7.1	0
Humber Gateway	Not available	1	99.2	5	2	100	2	2	5.4	0	1	7.1	0
Hywind	Band (2012)	1	99.2	7				2	5.4	0	0	7.1	0
Kentish Flats Extension	Band (2012)	1	99.2	2				1	5.4	0	0	7.1	0
Lincs	Band (2000)	1	99.2	2	1	100	1	1	5.4	0	1	7.1	0
London Array	Band (2000)	1	99.2	4				1	5.4	0	2	7.1	0
Moray Firth Project One (MORL)	Band (2012)	3	98	53				2	5.4	0	7	7.1	1
Neart na Gaoithe	Band (2012)	1	99.2	40				18	5.4	1	11	7.1	1

[12] Grey shading represents projects which fall outside of foraging range from SPA colonies and therefore no data is considered in the breeding season.

Project	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding season			Post-breeding			Pre-breeding		
					No. of collisions	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*	*No. of collisions*	*Apportioning*	*pSPA collisions*
Race Bank	Band (2000)	1	99.2	23	1	100	1	17	5.4	1	4	7.1	0
Teesside	Band (2000)	1	99.2	59				18	5.4	1	2	7.1	0
Thanet	Band (2000)	1	99.2	0				0	5.4	0	0	7.1	0
Triton Knoll	Band (2000)	1	99.2	152	12	100	12	91	5.4	5	49	7.1	4
Westermost Rough	Band *et al.* (2007)	1	99.2	0	0	100	0	0	5.4	0	0	7.1	0
Tier 1 total							**35**			**13**			**10**
Tier 2													
Dogger Bank Creyke Beck Projects A and B	Band (2012)	3	98	218	87	16.8	15	41	5.4	2	90	7.1	6
Dogger Bank Teesside Projects A and B[13]	Band (2012)	3	98	136				28	5.4	2	66	7.1	5
East Anglia Three	Band (2012)	3	98	88				54	5.4	3	25	7.1	2
Inch Cape	Band (2012)	1	99.2	219				163	5.4	9	45	7.1	3
Kincardine	Band (2012)	4	98	61				25	5.4	1	3	7.1	0
Methil	Band (2011/12)	1	99.2	1				0	5.4	0	0	7.1	0
Seagreen Alpha	Band (2012)	3	98	172				79	5.4	4	52	7.1	4
Seagreen Bravo	Band (2012)	3	98	121				50	5.4	3	30	7.1	2
Tier 2 total							**15**			**24**			**22**
Overall total							**50**			**37**			**32**

[13] Dogger Bank Teesside B is now called Sofia offshore wind farm

Puffin

<u>Operation/maintenance</u>

Displacement

7.7.2.39 There is no predicted mortality of breeding adult puffin and only a negligible predicted mortality for immature puffin associated with the breeding colony of the FFC pSPA as a result of displacement from Hornsea Three in any biological season. Hornsea Three will therefore not materially affect the current predicted in-combination impact for puffin from FFC pSPA.

Razorbill

<u>Operation/maintenance</u>

Displacement

7.7.2.40 There is no predicted mortality of breeding adult razorbill and only a negligible predicted mortality for immature razorbill associated with the breeding colony of the FFC pSPA as a result of displacement from Hornsea Three in any biological season. Hornsea Three will therefore not materially affect the current predicted in-combination impact for puffin from FFC pSPA.

Guillemot

<u>Operation/maintenance</u>

Disturbance/displacement

7.7.2.41 The predicted displacement of guillemot from other wind farm projects is summarised in Table 7.40 for the breeding and non-breeding seasons.

<u>*Breeding season*</u>

7.7.2.42 There is no predicted mortality of breeding adult guillemot associated with the breeding colony of the FFC pSPA as a result of displacement from Hornsea Three in the breeding season. The current level of in-combination displacement mortality in the breeding season from those Tier 1 offshore wind farms identified in Table 7.40 is considered to be 36-181 birds and for Tier 2 wind farms is 118-590 birds (Table 7.43).

7.7.2.43 The population of guillemot at the pSPA has increased considerably in recent years. The observed rate of increase in the number of guillemot at the pSPA was approximately 3.2% per year between 1987 and 2017 and 3.6% per year between 2000 and 2017. The maximum predicted growth rate for this species is 7.1%, calculated using the method proposed by Niel & Lebreton (2005).

7.7.2.44 PVA modelling for the FFC pSPA population of guillemot has previously been conducted as part of the assessments presented for the Hornsea Project Two offshore wind farm (MacArthur Green, 2015). Those models assumed a project life time of 25 years whereas the operational life of Hornsea Three is expected to be 35 years. Two outputs from that PVA modelling are considered in this assessment: change in median population growth rate and counterfactual of population size (M. Trinder pers. comm.) and so the changes predicted in growth rate over 25 years are appropriate for inference here without any need for correction. In contrast, estimates of the counterfactual of population size, are dependent on the period over which they are calculated. However it is possible to obtain an approximate prediction for the output at 35 years through extrapolation of the values obtained after 5, 10, 15, 20 and 25 years (M. Trinder pers. comm.). This approach can be used for both the density independent and density dependent versions of the model, although the nonlinearity of the density dependent predictions reduces the degree of confidence which can be placed in this approach. However, this version of the model predicts changes of lower magnitude to those predicted by the density independent version of the model and this relative difference is expected to remain even at 35 years. The differences in predictions at 25 years are included here for reference to highlight the conservatism of the density independent model.

7.7.2.45 Based on modelled impacts of 50 and 200 guillemots (the closest modelled impacts to the Tier 1 in-combination displacement total range) the median growth rate would be expected to decline by 0.06-0.26% (density independent PVA model excluding any immigration). The resulting population of guillemot at FFC pSPA after 25 years would therefore be expected to represent 94.5-98.7% (and when extrapolated to 35 years, approximately 92.1-98.3%) of the population that would occur without the presence of in-combination wind farms. A density dependent model was also run, with this predicting a lesser change in growth rate, approximately 0.03-0.12% and consequently a higher ratio of impacted to unimpacted median population size after 25 years (96.9-99.3%).

7.7.2.46 For Tier 2 projects, based on modelled impacts of 100 and 600 birds, the median growth rate would be expected to decline by 0.13-0.77% (density independent PVA model excluding any immigration). The resulting population of guillemot at FFC pSPA after 25 years would therefore be expected to represent 83.8-97.2% (and when extrapolated to 35 years, approximately 77.0-96.2%) of the population that would occur without the presence of in-combination wind farms. A density dependent model was also run, with this predicting a lesser change in growth rate, approximately 0.06-0.38% and consequently a higher ratio of impacted to unimpacted median population size after 25 years (96.9-99.3%).

7.7.2.47 The current population at the pSPA (60,887 pairs) is approximately 46% higher than the cited population and the population has increased 95% since the Seabird 2000. PVA modelling predicts that the population of guillemot at FFC pSPA would still continue to increase however, over the lifetime of Hornsea Three the resultant population would be 1.7-7.9% lower than the population that would occur without the presence of Tier 1 projects. Therefore there is no indication that additional mortality from Hornsea Three alone or in-combination would result in the population declining below the cited population.

7.7.2.48 On this basis, there is no indication that, at the level of mortality predicted to arise in-combination, the population is likely to decline, over a period of 35 years, to an extent that would mean that the breeding guillemot population of the FFC pSPA would no longer be considered to be in favourable condition.

7.7.2.49 In addition to breeding adult birds displacement mortality will also affect immature and non-breeding birds. Hornsea Three is predicted to affect 134-669 immature guillemot although as immature birds are not constrained to certain areas during the breeding season it is considered that the appropriate mortality rate is towards the lower end of the range presented. However, it is not known what proportion of this impact, or impacts on immature birds at other projects considered in-combination can be attributed to FFC pSPA.

7.7.2.50 Immature birds are known to visit colonies before age of first breeding, with immature birds not constrained to certain areas during the breeding season, unlike breeding birds (Furness, 2015). It is likely that the majority of the impact on immature birds associated with FFC pSPA will occur at projects for which FFC pSPA is the closest breeding colony especially for older immatures which are likely to show greater affinity for their natal colony. However, the total population present at these projects will likely consist of birds from a number of breeding colonies including FFC pSPA (41,607 pairs), the Farne Islands (32,855 pairs in 2016), St Abb's to Fast Castle SPA (24,258 pairs in 2016) and the Firth of Forth (21,181 pairs in 2015). Therefore the total in-combination impact on immature birds would have to be apportioned between a large regional BDMPS population composed of immature birds associated with a number of breeding colonies.

7.7.2.51 Impacts on immature birds have less of an impact on the population as a whole when compared to impacts on breeding adult birds. This is due to differences in survival rates (fewer immature birds are expected to survive from one year to the next) and reductions in overall productivity of the population in a given year if breeding adult birds are lost. The PVA modelling presented in MacArthur Green (2015) already accounts for an impact on immature age classes from those projects included in the breeding season assessment (see Table 7.40) by applying additional mortality to all immature age classes in proportion to their presence (i.e. based on the PVA stable age structure) in addition to the total breeding adult impact. This does not account, however, for immature mortality at sites where there is no breeding adult mortality, such as Hornsea Three.

7.7.2.52 Whilst a predicted mortality of immature birds at Hornsea Three can be estimated, it is not known what proportion of these would be associated with the FFC pSPA or any of the other breeding colonies which contribute to a regional immature BDMPS population. However, the sensitivity of the breeding population to additional mortality of immature birds has been tested against the PVA model outputs.

7.7.2.53 PVA modelling has considered the effect of mortality up to 1,600 adults per annum (this simply reflects a limit of the modelling undertaken rather than a limit on a sustainable level of mortality) which implies, in addition, the mortality of approximately 1,116 immature birds. This level of immature mortality is likely to far exceed that predicted, but even at this level a change in growth rate that would prevent the colony from continuing to increase in size is not predicted. Since 2000, the average growth rate of the guillemot population at FFC pSPA was approximately 3.9% and the maximum change predicted is considerably less than this at 0.96-2.0%.

Non-breeding season

7.7.2.54 During the non-breeding season in-combination displacement arising from Tier 1 projects potentially affects 2,426 birds (Table 7.42), which leads to mortality of 12 individuals (assuming displacement of 50% and mortality of 1%). If Tier 2 projects are included, the number of birds affected is 3,630, which leads to (Table 7.44) mortality of 18 individuals (assuming displacement of 50% and mortality of 1%). The predicted mortality comprises 0.022% of the pSPA breeding population (41,607 pairs) and an increase in baseline mortality (5,076 individuals) of 0.35%.

7.7.2.55 For immature birds, displacement analysis predicts mortality of nine immature guillemot in the non-breeding season based on a displacement rate of 50% and a mortality rate of 1%.

7.7.2.56 It is assessed that there is no potential for an adverse effect on the integrity of the guillemot population of the FFC pSPA as a result of disturbance / displacement effects of Hornsea Three alone or in-combination with other plans and projects.

Conclusion

7.7.2.57 Hornsea Three is predicted to contribute a negligible number of breeding adult birds to the total number of breeding adult birds impacted by displacement mortality with any contribution from Hornsea Three occurring in the non-breeding season only. However, Hornsea Three may contribute to the overall in-combination impact on immature birds associated with FFC pSPA. Impacts on immature birds, when compared to those on adult birds, will not have as large an impact on the overall FFC pSPA as would impacts on adult birds due to differences in survival rates (fewer immature birds are expected to survive from one year to the next) and reductions in overall productivity of the population in a given year if breeding adult birds are lost. In addition, there is likely to be a large population of immature guillemot in the North Sea, with those immatures present at Hornsea Three in the breeding season likely to be associated with a number of large breeding colonies on the east coast of the UK. As such, any impact from Hornsea Three, in addition to that predicted at other offshore wind farms that are located close to FFC pSPA, would be attributable to a large population of immatures, reducing the impact on FFC pSPA. PVA modelling predicts that an impact significantly larger than the largest impact modelled in MacArthur Green (2015) and significantly larger than the current maximum level of in-combination mortality would be required in order for the median growth rate to reduce to a level that would cause negative population level effects (i.e. a growth rate lower than that exhibited by the colony in recent years).

7.7.2.58 Therefore there is considered to be no indication that, at the level of mortality predicted to arise from Hornsea Three in–combination with other projects, the population is likely to decline, over a period of 35 years, to an extent that would mean that the breeding guillemot population of the FFC pSPA would no longer be considered to be in favourable condition.

Table 7.40: Predicted in-combination displacement mortality for guillemot[14].

Project	Mean-peak population in breeding season	Mean-peak population in non-breeding season	Breeding season apportioning (%)	Non-breeding apportioning (%)	Mean-peak population apportioned to the pSPA in the breeding season[15]	Mean-peak population apportioned to the pSPA in the non-breeding season
Hornsea Project Three		17,772		4.4		784
Tier 1						
Aberdeen		225		4.4		10
Beatrice		2755		4.4		122
Blyth Demonstration	1220	1321	12.1	4.4	148	58
Dudgeon	334	542	12.1	4.4	41	24
East Anglia One		640		4.4		28
Galloper		593		4.4		26
Greater Gabbard		548		4.4		24
Hornsea Project One	9836	8097	12.1	4.4	1194	357
Hornsea Project Two	7735	13164	12.1	4.4	939	581
Humber Gateway	99	138	100	4.4	99	6
Hywind		0		4.4		0
Lincs and LID6	582	814	12.1	4.4	71	36
London Array I & II		377		4.4		17
Moray		547		4.4		24
Neart na Gaoithe		3761		4.4		166
Race Bank	361	708	12.1	4.4	44	31
Sheringham Shoal	390	715	12.1	4.4	47	32
Teesside	267	901	100	4.4	267	40
Thanet		124		4.4		5
Triton Knoll	425	746	100	4.4	425	33
Westermost Rough	347	486	100	4.4	347	21
Tier 1 total					**3,621**	**2,426**

[14] Grey shading represents projects which fall outside of foraging range from SPA colonies and therefore no data is considered in the breeding season.

[15] Apportioning in the breeding season has been conducted assuming that 100% of the birds present at a wind farm that is within mean-maximum foraging range are adult birds associated with FFC pSPA. For projects between mean-maximum and maximum foraging range the apportioning value calculated in SMartWind (2015a) has been used (i.e. 12.1%)

Project	Mean-peak population in breeding season	Mean-peak population in non-breeding season	Breeding season apportioning (%)	Non-breeding apportioning (%)	Mean-peak population apportioned to the pSPA in the breeding season[15]	Mean-peak population apportioned to the pSPA in the non-breeding season
Tier 2						
Dogger Bank Creyke Beck A	5407	6142	35.0	4.4	1892	271
Dogger Bank Creyke Beck B	9479	10621	35.0	4.4	3318	469
Dogger Bank Teesside A	3283	2268	35.0	4.4	1149	100
Dogger Bank Teesside B[16]	5211	3701	35.0	4.4	1824	163
East Anglia Three		1396		4.4		62
Inch Cape		3177		4.4		140
Kincardine		0		4.4		0
Seagreen A		0		4.4		0
Seagreen B		0		4.4		0
Tier 2 total					**8,183**	**1,205**
Overall total					**11,804**	**3,630**

[16] Now Sofia Offshore Wind Farm

Table 7.41: Predicted in-combination guillemot mortality from FFC pSPA as a result of displacement during the breeding season (Tier 1 projects only).

	Mortality rate (%)											
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	7	18	36	72	109	145	181	217	253	290	326	362
20	7	14	36	72	145	217	290	362	435	507	579	652	724
30	11	22	54	109	217	326	435	543	652	760	869	978	1086
40	14	29	72	145	290	435	579	724	869	1014	1159	1304	1448
50	18	36	91	181	362	543	724	905	1086	1267	1448	1629	1810
60	22	43	109	217	435	652	869	1086	1304	1521	1738	1955	2173
70	25	51	127	253	507	760	1014	1267	1521	1774	2028	2281	2535
80	29	58	145	290	579	869	1159	1448	1738	2028	2317	2607	2897
90	33	65	163	326	652	978	1304	1629	1955	2281	2607	2933	3259
100	36	72	181	362	724	1086	1448	1810	2173	2535	2897	3259	3621

	< 1% background mortality
	> 1% background mortality/<1% SPA population
	> 1% SPA population

Table 7.42: Predicted in-combination guillemot mortality from FFC pSPA as a result of displacement during the non-breeding season (Tier 1 projects only).

	Mortality rate (%)											
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	2	5	12	24	49	73	97	121	146	170	194	218	243
20	5	10	24	49	97	146	194	243	291	340	388	437	485
30	7	15	36	73	146	218	291	364	437	509	582	655	728
40	10	19	49	97	194	291	388	485	582	679	776	873	970
50	12	24	61	121	243	364	485	607	728	849	970	1092	1213
60	15	29	73	146	291	437	582	728	873	1019	1164	1310	1456
70	17	34	85	170	340	509	679	849	1019	1189	1359	1528	1698
80	19	39	97	194	388	582	776	970	1164	1359	1553	1747	1941
90	22	44	109	218	437	655	873	1092	1310	1528	1747	1965	2183
100	24	49	121	243	485	728	970	1213	1456	1698	1941	2183	2426

	< 1% background mortality
	> 1% background mortality/<1% SPA population
	> 1% SPA population

Table 7.43: Predicted in-combination guillemot mortality from FFC pSPA as a result of displacement during the breeding season (Tier 1 and 2 projects).

	Mortality rate (%)											
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	12	24	59	118	236	354	472	590	708	826	944	1062	1180
20	24	47	118	236	472	708	944	1180	1416	1653	1889	2125	2361
30	35	71	177	354	708	1062	1416	1771	2125	2479	2833	3187	3541
40	47	94	236	472	944	1416	1889	2361	2833	3305	3777	4249	4722
50	59	118	295	590	1180	1771	2361	2951	3541	4131	4722	5312	5902
60	71	142	354	708	1416	2125	2833	3541	4249	4958	5666	6374	7082
70	83	165	413	826	1653	2479	3305	4131	4958	5784	6610	7437	8263
80	94	189	472	944	1889	2833	3777	4722	5666	6610	7555	8499	9443
90	106	212	531	1062	2125	3187	4249	5312	6374	7437	8499	9561	10624
100	118	236	590	1180	2361	3541	4722	5902	7082	8263	9443	10624	11804
	< 1% background mortality				> 1% background mortality/<1% SPA population					> 1% SPA population			

Table 7.44: Predicted in-combination guillemot mortality from FFC pSPA as a result of displacement during the non-breeding season (Tier 1 and 2 projects).

	Mortality rate (%)											
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	7	18	36	73	109	145	182	218	254	290	327	363
20	7	15	36	73	145	218	290	363	436	508	581	653	726
30	11	22	54	109	218	327	436	545	653	762	871	980	1089
40	15	29	73	145	290	436	581	726	871	1016	1162	1307	1452
50	18	36	91	182	363	545	726	908	1089	1271	1452	1634	1815
60	22	44	109	218	436	653	871	1089	1307	1525	1742	1960	2178
70	25	51	127	254	508	762	1016	1271	1525	1779	2033	2287	2541
80	29	58	145	290	581	871	1162	1452	1742	2033	2323	2614	2904
90	33	65	163	327	653	980	1307	1634	1960	2287	2614	2940	3267
100	36	73	182	363	726	1089	1452	1815	2178	2541	2904	3267	3630
	< 1% background mortality				> 1% background mortality/<1% SPA population					> 1% SPA population			

7.7.3 Coquet Island SPA

Fulmar

Operation/maintenance

Displacement

7.7.3.1 There is little quantitative information on the potential displacement of fulmar from other wind farm projects that may act in-combination with Hornsea Three. However, Hornsea Three is unlikely to contribute a significant amount of additional mortality relative to the amount that may already occur at projects that may act in-combination. For example, at Hornsea Three displacement mortality in the all seasons is less than one bird.

Conclusion

7.7.3.2 The displacement mortality predicted for Hornsea Three is considered unlikely to materially alter the current in-combination displacement impact for fulmar at Coquet Island SPA. On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three, this will result in an adverse effect on the site integrity of Coquet Island SPA.

7.7.4 Farne Islands SPA

Fulmar

Operation/maintenance

Displacement

7.7.4.1 There is little quantitative information on the potential displacement of fulmar from other wind farm projects that may act in-combination with Hornsea Three. However, Hornsea Three is unlikely to contribute a significant amount of additional mortality relative to the amount that may already occur at projects that may act in-combination. For example, at Hornsea Three displacement mortality in all seasons is less than one bird.

Conclusion

7.7.4.2 The displacement mortality predicted for Hornsea Three is considered unlikely to materially alter the current in-combination displacement impact for fulmar at the Farne Islands SPA. On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three, this will result in an adverse effect on the site integrity of the Farne Islands SPA.

7.7.5 Forth Islands SPA

Fulmar

Operation/maintenance

Displacement

7.7.5.1 There is little quantitative information on the potential displacement of fulmar from other wind farm projects that may act in-combination with Hornsea Three. However, Hornsea Three is unlikely to contribute a significant amount of additional mortality relative to the amount that may already occur at projects that may act in-combination. For example, at Hornsea Three displacement mortality in the breeding season is up to one bird with less than one bird estimated for the post-, non- and pre-breeding seasons.

Conclusion

7.7.5.2 The displacement mortality predicted for Hornsea Three is considered unlikely to materially alter the current in-combination displacement impact for fulmar at the Forth Islands pSPA. On this basis, there is no indication that, at the level of mortality predicted to arise from Hornsea Three, this will result in an adverse effect on the site integrity of the Forth Islands pSPA.

7.8 Summary

7.8.1.1 The screening process indicated that LSE on the interest features of the Coquet Island SPA, Greater Wash pSPA Farne Islands SPA, FFC pSPA, Forth Islands SPA and North Norfolk Coast SPA could not be discounted and so a systematic assessment of the potential for an adverse effect on the integrity of each site has been undertaken.

7.8.1.2 The assessment has considered the potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, alone and in-combination with other relevant plans and projects with respect to each site’s Conservation Objectives.

7.8.1.3 There is no indication that the construction, operation and maintenance or decommissioning will lead to a significant change in the extent and distribution of the habitats of any of the qualifying features for all these sites.

7.8.1.4 There is no indication that the structure and function of the habitats of the qualifying features will be significantly altered, nor the supporting processes on which those habitats rely. In each case the distribution of qualifying features within each site will also be maintained.

7.8.1.5 With respect to the population of each of the qualifying features, the likely mortality arising from the construction and operation of Hornsea Three alone and in-combination with other plans and projects (other offshore wind farms in this case) has been predicted. There is no indication of an adverse effect on any of the populations at the SPAs identified during the screening process

7.8.1.6 These conclusions are summarised in Table 7.45 below.

Table 7.45: Summary of conclusions: offshore ornithology

<table>
<tr><th>Site</th><th>Feature</th><th>Project phase</th><th>Potential Impact</th><th>Conclusion Project alone</th><th>Conclusion project in-combination with other plans and projects</th></tr>
<tr><td>Coquet Island SPA</td><td>• Fulmar</td><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td rowspan="4">Greater Wash pSPA and North Norfolk Coast SPA (Sandwich tern only)</td><td rowspan="2">• Red-throated diver
• Common scoter</td><td>Construction/ Decommissioning</td><td>• Disturbance</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td rowspan="2">• Sandwich tern</td><td rowspan="2">Construction/ Decommissioning</td><td>• Disturbance</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>• Changes to prey availability</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>Farne Islands SPA</td><td>• Fulmar</td><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td rowspan="5">FFC pSPA/Flamborough Head and Bempton Cliffs SPA</td><td>• Gannet</td><td>Operation</td><td>• Collision risk
• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>• Kittiwake</td><td>Operation</td><td>• Collision risk</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>• Puffin</td><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>• Razorbill</td><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>• Guillemot</td><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
<tr><td>Forth Islands SPA</td><td>• Fulmar</td><td>Operation</td><td>• Displacement</td><td>No adverse effect on site integrity predicted</td><td>No adverse effect on site integrity predicted</td></tr>
</table>

8. Assessment of Adverse Effects on Integrity: onshore ecology

8.1 Introduction

8.1.1.1 The screening exercise (Stage 1 of the HRA process) identified potential for LSEs on the onshore ecology features of the sites listed in Table 8.1 and shown in Figure 8.1.

8.1.1.2 The RIAA has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2016). The final assessment for each effect is based upon expert judgement.

8.2 Conservation Objectives

8.2.1.1 Due to the variation in the types of qualifying features assessed within this section (Annex I habitats, Annex II species and SPA features), the Conservation Objectives are detailed with each assessment.

8.3 Potential impacts

8.3.1.1 The screening exercise (Stage 1 of the HRA process) identified potential for LSEs on the terrestrial Annex I habitat features of the sites listed in Table 8.1 and shown in Figure 8.1.

8.4 Baseline information

8.4.1.1 As with the Conservation Objectives, due to the variation in the types of qualifying features assessed within this section (Annex I habitats, Annex II species and SPA features), the baseline information is detailed with each assessment.

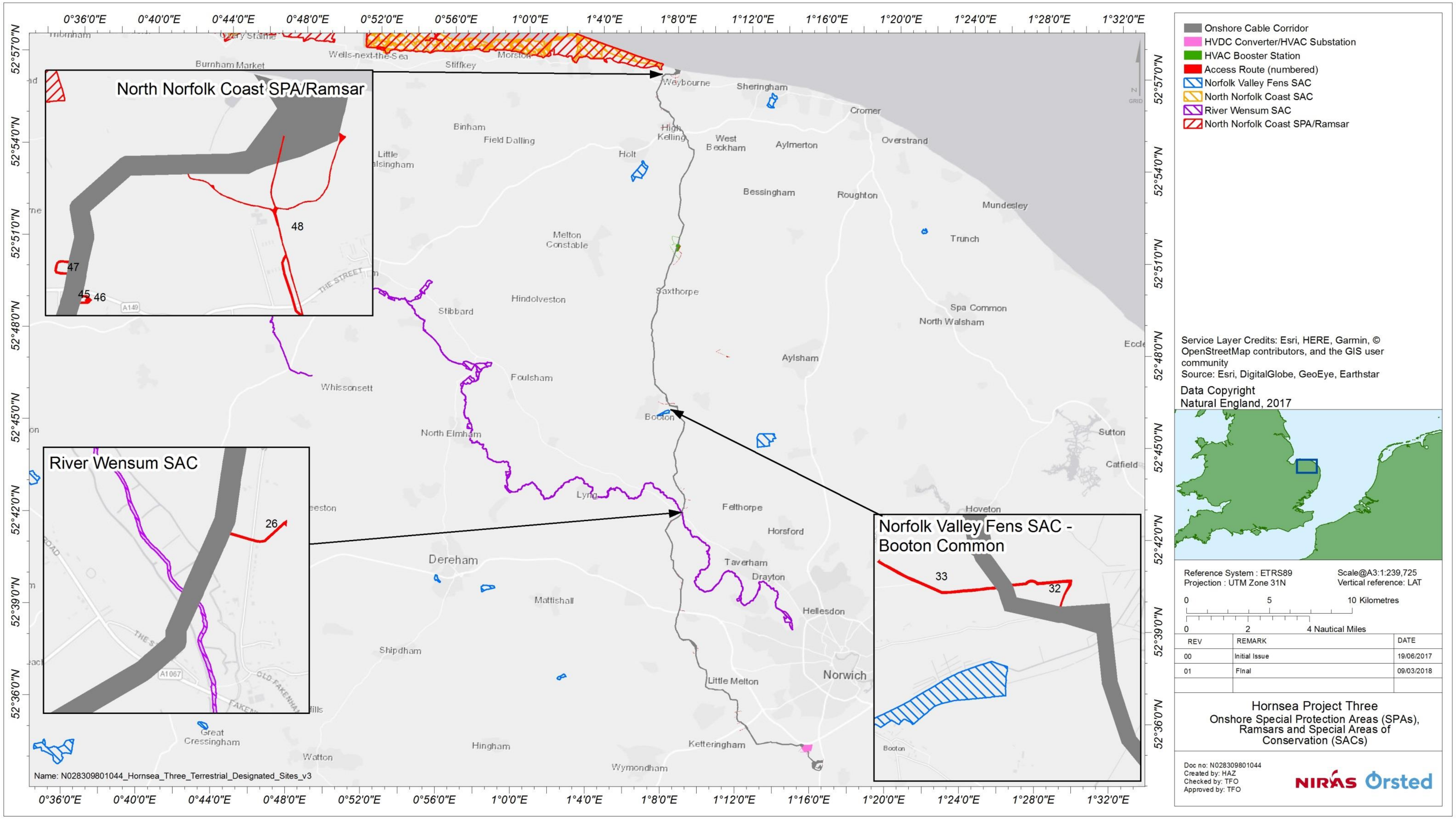
Table 8.1: European sites and features for which LSE have been identified for onshore ecology.

Site	Feature	Project phase	Effect
Annex I habitats			
Norfolk Valley Fens SAC	• Alkaline fens (Calcium-rich springwater-fed fens) • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*). (Alder woodland on floodplains) • Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. (Calcium-rich fen dominated by great fen sedge (saw sedge)) • European dry heaths • Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*). (Purple moor-grass meadows) • Northern Atlantic wet heaths with *Erica tetralix* (Wet heathland with cross-leaved heath) • Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) (Dry grasslands and scrublands on chalk or limestone)	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
Wensum River SAC	• Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; Rivers with floating vegetation often dominated by water-crowfoot	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
North Norfolk Coast SAC	• Coastal lagoons • Fixed dunes with herbaceous vegetation (grey dunes). (Dune grassland) • Embryonic shifting dunes • Humid dune slacks • Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*). (Mediterranean saltmarsh scrub) • Perennial vegetation of stony banks. (Coastal shingle vegetation outside the reach of waves) • Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes). (Shifting dunes with marram).	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
North Norfolk Coast Ramsar Site	• **Ramsar criterion 1:** • The site is one of the largest expanses of undeveloped coastal habitat of its type in Europe. It is a particularly good example of a marshland coast with intertidal sand and mud, saltmarshes, shingle banks and sand dunes. There are a series of brackish-water lagoons and extensive areas of freshwater grazing marsh and reed beds. • **Ramsar criterion 2:** • Supports at least three British Red Data Book and nine nationally scarce vascular plants, one British • Red Data Book lichen and 38 British Red Data Book invertebrates.	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
Annex II species			
Norfolk Valley Fens SAC	• • Narrow-mouthed whorl snail *Vertigo angustior* • Desmoulin's whorl snail *Vertigo moulinsiana*	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species

Site	Feature	Project phase	Effect
Wensum River SAC	• Desmoulin`s whorl snail *Vertigo moulinsiana* • White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes* • Brook lamprey *Lampetra planeri* • Bullhead *Cottus gobio*	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
North Norfolk Coast SAC	• Otter *Lutra lutra* • Petalwort *Petalophyllum ralfsii*	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
Ornithology			
North Norfolk Coast SPA	• **Annex 1 species (qualified under Article 4.1):** • During the breeding season: • Avocet *Recurvirostra avosetta,* • Bittern *Botaurus stellaris* • Marsh harrier *Circus aeruginosus* • Over winter: • Avocet *Recurvirostra avosetta* • Bar-tailed Godwit *Limosa lapponica* • Bittern *Botaurus stellaris* • Golden Plover *Pluvialis apricaria* • Hen Harrier *Circus cyaneus* • Ruff *Philomachus pugnax* • **Migratory species (qualified under Article 4.2):** • During the breeding season:	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Habitat fragmentation • Accidental pollution • Invasive non-native species

Site	Feature	Project phase	Effect
	• Redshank *Tringa totanus* • Ringed Plover *Charadrius hiaticula* • On passage: • Ringed Plover *Charadrius hiaticula* • Over-winter: • Dark-bellied Brent Goose *Branta bernicla bernicla* • Knot *Calidris canutus* • Pink-footed Goose *Anser brachyrhynchus* • Pintail *Anas acuta* • Redshank *Tringa totanus* • Wigeon *Anas penelope* • **Waterfowl assemblage (qualified under Article 4.2):** • Over winter, the area regularly supports 91,249 individual waterfowl (5 year peak mean 1991/2 - 1995/6) including: Shelduck *Tadorna tadorna*, Avocet, Golden Plover, Ruff , Bar-tailed Godwit *Limosa lapponica*, Pink-footed Goose *Anser brachyrhynchus*, Dark-bellied Brent *Goose Branta bernicla bernicla*, Wigeon *Anas penelope*, Pintail *Anas acuta*, Knot *Calidris canutus,* Redshank *Tringa totanus*, Bittern *Botaurus stellaris*, White-fronted Goose *Anser albifrons albifrons*, Dunlin *Calidris alpina alpina,* Gadwall *Anas strepera*, Teal *Anas crecca*, Shoveler *Anas clypeata*, Common Scoter *Melanitta nigra*, Velvet Scoter *Melanitta fusca*, Oystercatcher *Haematopus ostralegus*, Ringed Plover *Charadrius hiaticula*, Grey Plover *Pluvialis squatarola*, Lapwing *Vanellus vanellus*, Sanderling *Calidris alba*, Cormorant *Phalacrocorax carbo.*	Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species
North Norfolk Coast Ramsar Site	• **Ramsar criterion 5:** • Species with peak counts in winter: 98462 waterfowl (5 year peak mean 1998/99-2002/2003). • **Ramsar criterion 6:** • On passage: • Knot *Calidris canutus* • Over-winter: • Dark-bellied Brent Goose *Branta bernicla bernicla* • Pink-footed Goose *Anser brachyrhynchus* • Pintail *Anas acuta* • Wigeon *Anas penelope*	Construction/Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species
		Operation/Maintenance	• Temporary disturbance/damage • Accidental pollution

Figure 8.1: Onshore European sites identified for further assessment



8.5 Assessment on adverse effect on site integrity - Annex I Habitats

8.5.1 Norfolk Valley Fens SAC

Site Description

8.5.1.1 The Norfolk Valley Fens SAC comprises a series of valley-head spring-fed fens which are very rare in the lowlands. The spring-heads are dominated by the small sedge fen type, mainly referable to black-bog-rush – blunt-flowered rush (*Schoenus nigricans* – *Juncus subnodulosus*) mire, but there are transitions to reedswamp and other fen and wet grassland types. The individual fens vary in their structure according to intensity of management and provide a wide range of variation. There is a rich flora associated with these fens, including species such as grass-of-Parnassus *Parnassia palustris*, common butterwort *Pinguicula vulgaris*, marsh helleborine *Epipactis palustris* and narrow-leaved marsh-orchid *Dactylorhiza traunsteineri*.

8.5.1.2 In places the calcareous fens grade into acidic flush communities on the valley sides. Purple moor-grass *Molinia caerulea* is often dominant with a variety of mosses including thick carpets of bog-moss *Sphagnum* spp. Marshy grassland may be present on drier ground and purple moor-grass is again usually dominant but cross-leaved heath *Erica tetralix* can be frequent. Alder *Alnus glutinosa* forms carr woodland in places by streams. Wet and dry heaths and acid, neutral and calcareous grassland surround the mires.

8.5.1.3 Within the Norfolk Valley Fens there are a number of marginal fens associated with pingos – pools that formed in hollows left when large blocks of ice melted at the end of the last Ice Age. These are very ancient wetlands and several support strong populations of Desmoulin's whorl snail *Vertigo moulinsiana* as part of a rich assemblage of rare and scarce species in standing water habitat. At Flordon Common a strong population of narrow-mouthed whorl snail *Vertigo angustior* occurs in flushed grassland with yellow iris *Iris pseudacorus*.

8.5.1.4 The nearest fen within the Norfolk Valley Fens SAC to the Hornsea Three onshore cable corridor is Booton Common SSSI (Figure 8.1). The Hornsea Three onshore cable corridor is 280 m from the Norfolk Valley Fens SAC with greater distances to permanent infrastructure. Access routes are located approximately 200 m from the Norfolk Valley Fens SAC at Booton Common (Figure 8.1).

Conservation Objectives

8.5.1.5 An AA requires the consideration of the impacts on the integrity of a European site, with regards to the site's structure and function and its Conservation Objectives. The Conservation Objectives of the Norfolk Valley Fens SAC, with regard to the habitats for which the site has been designated, are as follows:

With regard to the SAC and the natural habitats and/or species for which the site has been designated (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 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 the habitats of qualifying species rely
- The populations of qualifying species, and,
- The distribution of qualifying species within the site.

Features screened into assessment

8.5.1.6 The features screened into the assessment include all Annex I habitats (see below) and Annex II species qualifying features (see section 8.6.2) in respect of all potential impacts (Table 8.1).

Baseline

8.5.1.7 An assessment of LSE was based on the spatial proximity between the Hornsea Three onshore cable corridor, including the location of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation, and the Norfolk Valley Fens SAC. Only the onshore cable corridor and associated access infrastructure are located near enough to the Norfolk Valley Fens SAC for an impact pathway to exist. An analysis of the distribution of Annex 1 habitat data for the area within the Norfolk Valley Fens SAC (Natural England, 2017c) identified that alkaline fens (calcium-rich springwater-fed fens) occur at Booton Common.

8.5.1.8 The following Annex I habitats are not known to occur where the Hornsea Three onshore cable corridor is likely to impact the Norfolk Valley Fens SAC:

- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*) (Alder woodland on floodplains);
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae* (Calcium-rich fen dominated by great fen sedge (saw sedge));
- European dry heath;
- *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) (Purple moor-grass meadows);
- Northern Atlantic wet heaths with *Erica tetralix* (Wet heathland with cross-leaved heath); and
- Semi-natural dry grasslands and scrubland facies: on calcareous substrates *(Festuco-Brometalia)* (Dry grasslands and scrublands on chalk or limestone).

8.5.1.9 As a result of the spatial separation, no adverse effect on site integrity will occur with respect to the above listed Annex I habitats for any of the likely significant effects during construction/decommissioning and/or operation and maintenance.

Potential impacts – construction/decommissioning

<u>Alkaline fens (calcium-rich springwater-fed fens)</u>

Permanent habitat loss

8.5.1.10 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, i.e. at the location of the onshore HVAC booster station, the onshore HVDC converter/HVAC substation and link boxes. Direct impacts have been, or will be avoided by the application of the following design measures:

- Selection of the Hornsea Three onshore cable corridor so that all installation occurs outside designated site boundaries; or
- Horizontal Directional Drilling (HDD), where the cable corridor cannot avoid a designated site.

8.5.1.11 There is a break of slope on the southern side of the valley within the Hornsea Three onshore cable corridor that suggests that groundwater flows within the onshore cable corridor do not feed directly into the Norfolk Valley Fens SAC at Booton Common SSSI but run downslope to the Blackwater Drain. HDD techniques will be used at Blackwater Drain and mitigation measures to control potential construction impacts are set out in the Outline CoCP which accompanies the application. The HDD crossing at Blackwater Drain is upstream of the SAC/SSSI but there are no direct surface water flows from the Hornsea Three onshore cable corridor into the valley fen, except for the Blackwater Drain itself. The Blackwater Drain forms the northern boundary of the Booton Common designated site and it is probable that the drain and the fen are hydraulically linked. A hydrological characterisation report has been prepared (volume 6, annex 2.4: Hydrological Characterisation Study), which outlines the interaction between hydrology and ecology.

<u>*Conclusion*</u>

8.5.1.12 The proposed design measures will avoid any permanent habitat loss within the Norfolk Valley Fens SAC. The buried export cables are not likely to impact groundwater flows into the hydrologically linked Blackwater Drain and therefore no adverse effect on site integrity is will occur with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting (physical, chemical or biological) process on which the habitats rely.

Temporary disturbance/ damage

8.5.1.13 An assessment of LSE was based on whether there is spatial overlap between the onshore cable corridor search area and the Norfolk Valley Fens SAC. As described above, it is proposed that direct impacts on the designated site will be avoided through design measures. Pre-construction studies will be carried out to identify sensitive habitats in the vicinity of large/sensitive watercourse crossing locations. Plans will be developed for the establishment of associated construction compounds and works sites, to minimise potential impacts.

<u>*Conclusion*</u>

8.5.1.14 The proposed design measures will avoid any temporary disturbance/damage within the Norfolk Valley Fens SAC and therefore no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or the supporting (physical, chemical or biological) process on which the habitats rely.

Accidental pollution

8.5.1.15 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas. Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP which accompanies the application. Measures to be taken during HDD in relation to handling of bentonite and the requirement for plans to be produced for HDD beneath watercourses (to minimise the risk of pollution) are included in the Outline CoCP.

8.5.1.16 The Blackwater Drain forms the northern boundary of the Booton Common designated site and it is probable that the drain and the fen are hydraulically linked. HDD is proposed at the Blackwater Drain which is probably hydrologically connected to Booton Common. and where practicable, the location of the start and end point of the HDD operation will be carefully selected to ensure that trenching up to the HDD locations will minimise the risk of run-off from trenching reaching the river.

<u>*Conclusion*</u>

8.5.1.17 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the risk to this Annex I habitat within the Norfolk Valley Fens SAC. The employment of an Ecological Clark of Works (ECoW) will ensure compliance with the PEMMP and therefore no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens).

Invasive non-native species

8.5.1.18 The introduction of invasive non-native species from contaminated construction equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. Himalayan balsam *Impatiens glandulifera* is known to be present at Booton Common (Natural England, 2014c). To minimise the risk of spreading invasive species to, from or within the Norfolk Valley Fens SAC, works will be carried out in accordance with a biosecurity protocol documented in the Outline CoCP. An ECoW will be employed for the duration of the construction phase to ensure compliance with measures included in the PEMMP.

<u>Conclusion</u>

8.5.1.19 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the Norfolk Valley Fens SAC and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore, no adverse effect on site integrity will occur with respect to a change in extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting (physical, chemical or biological) processes on which the habitats rely.

Potential impacts – operation

<u>Alkaline fens (calcium-rich springwater-fed fens)</u>

Accidental pollution

8.5.1.20 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.5.1.21 As described above, it is proposed that operational activities will take place at either end of the HDD cable section and outside of the Norfolk Valley Fens SAC. Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline EMP which accompanies the application. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

<u>Conclusion</u>

8.5.1.22 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the risk to the Annex I habitat within the Norfolk Valley Fens SAC. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens).

Invasive non-native species

8.5.1.23 The introduction of invasive non-native species from contaminated maintenance equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. Himalayan balsam *Impatiens glandulifera* is known to be present at Booton Common (Natural England, 2014c). To minimise the risk of spreading invasive species to, from or within the Norfolk Valley Fens SAC, works will be carried out in accordance with a biosecurity protocol which will be documented in the EMP.

<u>Conclusion</u>

8.5.1.24 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the Norfolk Valley Fens SAC. Therefore, no adverse effect on site integrity will occur with respect to a change in extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting (physical, chemical or biological) processes on which the habitats rely.

8.5.2 River Wensum SAC

Site Description

8.5.2.1 The River Wensum is a naturally enriched, calcareous lowland river. The upper reaches are fed by springs that rise from the chalk and by run-off from calcareous soils rich in plant nutrients. This gives rise to beds of submerged and emergent vegetation characteristic of a chalk stream. Lower down, the chalk is overlain with boulder clay and river gravels, resulting in aquatic plant communities more typical of a slow-flowing river on mixed substrate. Much of the adjacent land is managed for hay crops and by grazing, and the resulting mosaic of meadow and marsh habitats, provides niches for a wide variety of specialised plants and animals.

8.5.2.2 *Ranunculus* vegetation occurs throughout much of the river's length. Stream water-crowfoot *R. penicillatus* ssp. *pseudofluitans* is the dominant *Ranunculus* species but thread-leaved water-crowfoot *R. trichophyllus* and fan-leaved water-crowfoot *R. circinatus* also occur in association with the wide range of aquatic and emergent species that contribute to this vegetation type. The river supports an abundant and rich invertebrate fauna including the native freshwater crayfish *Austropotamobius pallipes* as well as a diverse fish community, including bullhead *Cottus gobio* and brook lamprey *Lampetra planeri*. In addition, the site has an abundant and diverse mollusc fauna which includes Desmoulin's whorl-snail *Vertigo moulinsiana*, which is associated with aquatic vegetation at the river edge and adjacent fens.

8.5.2.3 The Hornsea Three onshore cable corridor is located within the River Wensum SAC with greater distances to permanent infrastructure (Figure 8.1).A section of the River Wensum SAC site, which accounts for an area of 0.003 km^2 (representing 0.001% of the total area of the SAC site) overlaps with the Hornsea Three onshore cable corridor (Figure 8.1).

Conservation Objectives

8.5.2.4 An AA requires the consideration of the impacts on the integrity of a European site, with regards to the site's structure and function and its Conservation Objectives. The Conservation Objectives of the River Wensum SAC are as follows:

With regard to the SAC and the natural habitats and/or species for which the site has been designated (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 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 the habitats of qualifying species rely;
- The populations of qualifying species, and
- The distribution of qualifying species within the site.

Features screened into assessment

8.5.2.5 The features screened into the assessment include all Annex I habitats (see below) and Annex II species qualifying features (see section 8.6.3) in respect of all potential impacts (Table 8.1).

Baseline

8.5.2.6 An assessment of LSE was based on the spatial proximity between the Hornsea Three onshore cable corridor (including the location of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation) and the River Wensum SAC. Only the export cable and associated access infrastructure are located near enough to the River Wensum SAC for an impact pathway to exist. Floating vegetation often dominated by water-crowfoot only occurs downstream of the point where the Hornsea Three onshore cable crosses the River Wensum; no Annex I habitats within the River Wensum SAC are known within the Hornsea Three onshore cable corridor footprint.

Potential impacts – construction/ decommissioning

Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (rivers with floating vegetation often dominated by water-crowfoot)

Permanent habitat loss

8.5.2.7 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, i.e. at the location of the onshore HVAC booster station, the onshore HVDC converter/HVAC substation and link boxes. It is proposed that direct impacts will be avoided by the application of Horizontal Directional Drilling (HDD), where the onshore cable corridor cannot avoid a designated site.

8.5.2.8 The Hornsea Three onshore cable corridor could result in the severance or impediment of ground water flows to the River Wensum, or Swannington Beck which flows into the River Wensum, with the potential to reduce the flows (volume, velocity and depth) within the river. Changes in flow regime are known to influence the extent and condition of floating vegetation often dominated by water-crowfoot (Hatton-Ellis & Grieve, 2003). The direction of the onshore cable corridor is approximately perpendicular to the direction of the waterways, i.e. in the same direction as the groundwater flows, and therefore groundwater flows will not likely be severed or impeded.

Conclusion

8.5.2.9 The Hornsea Three onshore cable corridor does not spatially overlap with areas of floating vegetation often dominated by water-crowfoot. Furthermore, no likely hydrological effects have been identified and therefore no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of this Annex I habitat within the River Wensum SAC or to the supporting (physical, chemical or biological) processes on which the habitats rely.

Temporary disturbance/damage

8.5.2.10 Temporary disturbance/damage will occur where natural or semi-natural habitats are subjected to activities that result in the removal of vegetation; the breaking up of the soil structure; and compaction by trackway, vehicles, personnel, equipment and stored materials. It is proposed that impacts will be avoided by the application of HDD under the River Wensum SAC. Where practicable, HDD will be employed at the water crossing point at Swannington Beck or employ silt traps or silt curtains downstream of the crossing points.

8.5.2.11 Pre-construction studies will be carried out to identify sensitive habitats in the vicinity of large/sensitive watercourse crossing locations and plans developed for the establishment of associated construction compounds and works sites, to minimise potential impacts (see Outline CoCP and Outline Ecological Management Plan).

8.5.2.12 The locations of the haul roads will be within the Hornsea Three onshore cable corridor which will avoid designated sites. The location of the start and end point of the crossing points will be carefully selected to ensure that location of the bridging points minimise the risk of temporary disturbance/damage.

Conclusion

8.5.2.13 The proposed design and construction measures will avoid any temporary habitat disturbance/damage within the River Wensum SAC and therefore no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot or the supporting (physical, chemical or biological) processes on which the habitats rely.

Accidental pollution

8.5.2.14 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.5.2.15 Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP. Measures to be taken during HDD in relation to handling of bentonite and the requirement for plans to be produced for HDD beneath watercourses (to minimise the risk of pollution) are included in the Outline CoCP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

8.5.2.16 HDD is proposed at the River Wensum and Swannington Beck which is hydrologically connected to the River Wensum. The location of the start and end point of the HDD operation will be carefully selected to ensure that trenching up to the HDD locations will be sufficiently distant from the watercourse that the risk of run-off from trenching reaching the river will be minimised.

Conclusion

8.5.2.17 The proposed design measures will avoid accidental pollution and the application of industry best practice (i.e. known effective mitigation) will minimise the residual risk within the River Wensum SAC. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot.

Invasive non-native species

8.5.2.18 The introduction of invasive non-native species from contaminated construction equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonica* are known to occur on the banks of the River Wensum (Natural England, 2014d). To minimise the risk of spreading invasive species to, from or within the River Wensum SAC, works will be carried out in accordance with a biosecurity protocol documented in the Outline CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the Outline EMP and CoCP.

Conclusion

8.5.2.19 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the River Wensum SAC and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore, no adverse effect on site integrity will occur with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot or to the supporting (physical, chemical or biological) processes on which it relies.

Potential impacts – operation

Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (rivers with floating vegetation often dominated by water-crowfoot)

Accidental pollution

8.5.2.20 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.5.2.21 As described above, it is proposed that operational activities will take place at either end of the HDD cable section and outside of the River Wensum SAC. Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline EMP. Measures will follow include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

8.5.2.22 The proposed design measures will avoid accidental pollution and the application of industry best practice (i.e. known effective mitigation) will minimise the risk to the Annex I habitat within the Norfolk Valley Fens SAC. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot.

Invasive non-native species

8.5.2.23 The introduction of invasive non-native species from contaminated maintenance equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonica* are known to occur on the banks of the River Wensum (Natural England, 2014d). To minimise the risk of spreading invasive species to, from or within the River Wensum SAC, works will be carried out in accordance with a biosecurity protocol documented in the EMP.

<u>Conclusion</u>

8.5.2.24 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the River Wensum SAC. Therefore no adverse effect on site integrity will occur with respect to a change in extent, distribution, structure and function of the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot or to the supporting (physical, chemical or biological) processes on which it relies.

8.5.3 North Norfolk Coast SAC

Introduction

8.5.3.1 The North Norfolk Coast SAC contains a large, active series of dunes on shingle barrier islands and spits and is little affected by development. The exceptional length and variety of the dune/beach interface is reflected in the high total area of embryonic dune. Sand couch *Elytrigia juncea* is the most prominent sand-binding grass. The site supports a large area of shifting dune vegetation, which is also varied but dominated by marram grass *Ammophila arenaria*. The fixed dunes are rich in lichens and drought-avoiding winter annuals such as common whitlowgrass *Erophila verna*, early forget-me-not *Myosotis ramosissima* and common cornsalad *Valerianella locusta*. The main communities represented are marram with red fescue *Festuca rubra* and sand sedge *Carex arenaria*, with lichens such as *Cetraria aculeata*. The dune slacks within this site are comparatively small and the Yorkshire-fog *Holcus lanatus* community predominates. They are calcareous and the communities occur in association with swamp communities.

8.5.3.2 Some of the slacks support the liverwort petalwort *Petalophyllum ralfsii*. In addition, the site supports otter *Lutra lutra*.

8.5.3.3 The Hornsea Three onshore cable corridor is located 0.32 km from the North Norfolk Coast SAC with greater distances to permanent infrastructure (Figure 8.1).

Conservation Objectives

8.5.3.4 An AA requires the consideration of the impacts on the integrity of a European site, with regards to the site's structure and function and its Conservation Objectives. The Conservation Objectives of the North Norfolk Coast SAC are as follows:

With regard to the SAC and the natural habitats and/or species for which the site has been designated (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 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 the habitats of qualifying species rely;
- The populations of qualifying species, and
- The distribution of qualifying species within the site.

Features screened into assessment

8.5.3.5 The features screened into the assessment include all Annex I habitats (see below) and Annex II species qualifying features (see section 8.6.4) with respect to all potential impacts (Table 8.1).

Baseline

8.5.3.6 An assessment of LSE was based on the spatial proximity between the Hornsea Three onshore cable corridor (including the location of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation) and the North Norfolk Coast SAC. Only the onshore cable corridor and associated access infrastructure are located near enough to the North Norfolk Coast SAC for an impact pathway to exist. No Annex I habitats associated with the North Norfolk SAC are known to occur within the Hornsea Three onshore cable corridor footprint.

Potential impacts – construction/decommissioning/operation and maintenance

<u>Conclusion</u>

8.5.3.1 No permanent loss or temporary disturbance/damage of habitats in the North Norfolk Coast SAC will occur during construction/decommissioning/operation and maintenance because of the spatial separation of the Hornsea Three onshore cable corridor and associated infrastructure.

8.5.3.2 There is no hydrological connection between the Hornsea Three onshore cable corridor and associated infrastructure and the North Norfolk Coast SAC and therefore there is no reasonably foreseeable impact pathway in respect of accidental pollution during construction/decommissioning/operation and maintenance.

8.5.3.3 The spatial separation between the Hornsea Three onshore cable corridor and the SAC is sufficiently large that there is no reasonably foreseeable impact pathway for invasive non-native species during construction/decommissioning/operation and maintenance.

8.5.3.4 Therefore, no adverse effect on site integrity will occur for construction/decommissioning and operation.

8.5.4 North Norfolk Coast Ramsar

Introduction

8.5.4.1 The North Norfolk Coast Ramsar site comprises one of the largest expanses of undeveloped coastal habitat of its type in Europe and is a notable example of marshland coast with intertidal sand and mud, saltmarshes, shingle banks and sand dunes, brackish-water lagoons and extensive areas of freshwater grazing marsh and reed beds. The site also supports at least three British Red Data Book and nine nationally scarce vascular plants, one British Red Data Book lichen and 38 British Red Data Book invertebrates.

8.5.4.2 The internationally important numbers of breeding, passage and winter waterbird species and the internationally important winter waterbird assemblage is described above in the onshore ornithology section of this report.

8.5.4.3 The Hornsea Three onshore cable corridor is located approximately 0.32 km from the North Norfolk Coast Ramsar with greater distances to permanent infrastructure (Figure 8.1).

Conservation Objectives

8.5.4.4 In accordance with Article 3.1 of the Ramsar Convention, the UK commit to the wise use of wetlands and in particular to maintain the ecological character of wetlands, i.e. the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

8.5.4.5 As the provisions on the Habitats Regulations relating to Habitat Regulations Assessments (HRAs) extend to Ramsar sites, Natural England considers the Conservation Advice packages for the overlapping European site designations to be, in most cases, sufficient to support the management of the Ramsar interests. As such the Conservation Objectives of the North Norfolk Coast SPA are applied to the Ramsar site.

Features screened into assessment

8.5.4.6 The features screened into the assessment, with respect to all likely significant effects, are the representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region; notably brackish-water lagoons and habitats supporting British Red Data Book and nationally scarce vascular plants, British Red Data Book lichen and British Red Data Book invertebrates (Table 8.1).

Baseline

8.5.4.7 An assessment of LSE was based on the spatial proximity between the Hornsea Three onshore cable corridor (including the location of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation) and the North Norfolk Coast Ramsar. Only the onshore cable corridor and associated access infrastructure are located near enough to the North Norfolk Coast Ramsar for an impact pathway to exist. The Hornsea Three onshore cable corridor and the North Norfolk Coast Ramsar are spatially separated by 0.32 km, therefore no habitats of the North Norfolk Coast Ramsar are within the Hornsea Three onshore cable corridor footprint.

Potential impacts – construction/decommissioning/operation and maintenance

Conclusion

8.5.4.8 No permanent loss or temporary disturbance/damage of habitats in the North Norfolk Coast Ramsar site will occur during construction/decommissioning/operation and maintenance because of the spatial separation of the Hornsea Three onshore cable corridor and associated access infrastructure.

8.5.4.9 There is no hydrological connection between the Hornsea Three onshore cable corridor and associated access infrastructure and the North Norfolk Coast Ramsar. Therefore there is no reasonably foreseeable impact pathway in respect of accidental pollution during construction/decommissioning/operation and maintenance.

8.5.4.10 The spatial separation between the Hornsea Three onshore cable corridor and the Ramsar site is sufficiently large that there is no reasonably foreseeable impact pathway for invasive non-native species during construction/decommissioning/operation and maintenance.

8.5.4.11 Therefore, no adverse effect on site integrity will occur for construction/decommissioning and operation.

8.6 Assessment of adverse effect on site integrity - Annex II species

8.6.1.1 The screening exercise (Stage 1 of the HRA process) identified potential for LSEs on the terrestrial Annex II species of the sites listed in Table 8.1 and shown in Figure 8.1.

8.6.2 Norfolk Valley Fens SAC

8.6.2.1 An introduction to the Norfolk Valley Fens SAC and its Conservation Objectives is presented in section 8.5.1.

Features screened into assessment

8.6.2.2 The features screened into the assessment with respect to all potential impacts are narrow-mouthed whorl snail *Vertigo angustior* and Desmoulin's whorl snail *V. moulinsiana* (Table 8.1).

Baseline

8.6.2.3 An assessment of LSE was based on the spatial proximity between the Hornsea Three onshore cable corridor and the Norfolk Valley Fens SAC accounting for the location of the proposed onshore HVAC booster station and the onshore HVDC converter/HVAC substation. Within the spatial overlap, narrow-mouthed whorl snail and Desmoulin's whorl snail are known to occur at Booton Common, however surveys for both species undertaken in 2017 (volume 6, annex 3.3: Desmoulin's Whorl Snail Survey) found no individuals.

Potential impacts — construction/decommissioning

Desmoulin's whorl snail — Narrow-mouthed whorl snail

Permanent habitat loss

8.6.2.4 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, i.e. at the location of the onshore HVAC booster station, the onshore HVDC converter/HVAC substation and link boxes. It is proposed that direct impacts will be avoided by the application of the following design measures:

- Selection of the Hornsea Three onshore cable corridor so that all installation occurs outside designated site boundaries; or
- HDD, where the Hornsea Three onshore cable corridor cannot avoid a designated site.

8.6.2.5 There is a break of slope on the southern side of the valley within the Hornsea Three onshore cable corridor that suggests that groundwater flows within the corridor do not feed directly into the Norfolk Valley Fens SAC at Booton Common SSSI but run downslope to the Blackwater Drain. The HDD crossing is upstream of the SAC/SSSI but there are no direct surface water flows from the Hornsea Three onshore cable corridor into the valley fen, except for the Blackwater Drain itself. The Blackwater Drain forms the northern boundary of the Booton Common designated site and it is probable that the drain and the fen are hydraulically linked. A hydrological characterisation report has been prepared (volume 6, annex 2.4: Hydrological Characterisation Study), which outlines the interaction between hydrology and ecology. HDD techniques will be used in this location and mitigation measures to control construction impacts are set out in the Outline CoCP.

Conclusion

8.6.2.6 The proposed design measures will avoid any permanent habitat loss within the Norfolk Valley Fens SAC. HDD is not likely to impact groundwater flows into the hydrologically linked Blackwater Drain and therefore no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Temporary disturbance/damage

8.6.2.7 Temporary disturbance/damage will occur where natural or semi-natural habitats are subjected to activities that result in the removal of vegetation; the breaking up of the soil structure; and compaction by trackway, vehicles, personnel, equipment and stored materials.

8.6.2.8 As described above, it is proposed that direct impacts on the designated site will be avoided. Where HDD is used, temporary compounds of 70 m x 70 m will be located at either end of the HDD crossing and as such will be located outside of the designated site.

8.6.2.9 Pre-construction studies will be carried out to identify sensitive habitats in the vicinity of large/sensitive watercourse crossing locations and plans developed for the establishment of associated construction compounds and works sites, to minimise potential impacts (see Outline CoCP and Outline EMP).

8.6.2.10 The locations of the haul roads will be within the Hornsea Three onshore cable corridor which avoids designated sites.

Conclusion

8.6.2.11 In the context of the likely absence of Desmoulin's whorl snail and narrow-mouthed whorl snail from the Hornsea Three onshore cable corridor, the proposed design measures will avoid any temporary habitat disturbance/damage within the Norfolk Valley Fens SAC. No adverse effect on site integrity will therefore occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Accidental pollution

8.6.2.12 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.6.2.13 Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP. Measures to be implemented during HDD in relation to handling of bentonite and the requirement for plans to be produced for HDD beneath watercourses (to minimise the risk of pollution) are included in the Outline CoCP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

8.6.2.14 HDD is proposed at the Blackwater Drain which is probably hydrologically connected to Booton Common. Where practicable, the location of the start and end point of the HDD operation will be carefully selected to ensure that trenching up to the HDD locations will be sufficiently distant from the watercourse that the risk of run-off from trenching reaching the river will be minimised.

Conclusion

8.6.2.15 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the Norfolk Valley Fens SAC. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Invasive non-native species

8.6.2.16 Himalayan balsam *Impatiens glandulifera* is known to be present at Booton Common (Natural England, 2014c). The presence of invasive non-native species can increase shade resulting in unsuitable conditions for Desmoulin's and narrow-mouthed whorl snail (Killeen, 2003; Moorkens & Killeen, 2011). To minimise the risk of spreading invasive species to the Norfolk Valley Fens SAC it is proposed that works will be carried out in accordance with a biosecurity protocol documented in the Outline CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the Outline EMP and CoCP.

Conclusion

8.6.2.17 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the Norfolk Valley Fens SAC and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore no adverse effect on site integrity will occur with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Potential impacts — operation

Desmoulin's whorl snail — Narrow-mouthed whorl snail

Accidental pollution

8.6.2.18 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

Conclusion

8.6.2.19 As described above, it is proposed that operational activities will take place at either end of the HDD cable section and outside of the Norfolk Valley Fens SAC. Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the EMP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Invasive non-native species

8.6.2.20 Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonica* are known to occur on the banks of the River Wensum (Natural England, 2014d). The presence of invasive non-native species can increase shade resulting in unsuitable conditions for Desmoulin's whorl snail (Killeen, 2003; Moorkens & Killeen, 2011) and potentially decrease water quality (Greenwood & Kuhn, 2014). To minimise the risk of spreading invasive species to the Norfolk Valley Fens SAC it is proposed that works will be carried out in accordance with a biosecurity protocol documented in the EMP

Conclusion

8.6.2.21 The proposed application a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the Norfolk Valley Fens SAC and adjacent wet habitats. Therefore no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

8.6.3 River Wensum SAC

8.6.3.1 An introduction to the River Wensum SAC and its Conservation Objectives is presented in section 8.5.2.

Features screened into assessment

8.6.3.2 Table 8.1 provides a summary of the outcomes of screening with respect to the River Wensum SAC. The features screened into the assessment are Desmoulin's whorl snail, white-clawed crayfish *Austropotamobius pallipes*, brook lamprey *Lampetra planeri* and bullhead *Cottus gobio*.

Baseline

8.6.3.3 An assessment of LSE was based on the spatial overlap between the Hornsea Three onshore cable corridor and the River Wensum SAC including the location of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation. Within the spatial overlap, Desmoulin's whorl snail is known to occur in the River Wensum SAC (volume 6, annex 3.3: Desmoulin's Whorl Snail Survey).

8.6.3.4 White-clawed crayfish are historically known from the River Wensum however signal crayfish have been known in the River Wensum downstream of Lenwade Mill since at least 2010 (Natural England, 2010). The presence of signal crayfish *Pacifastacus leniusculus* means that the white-clawed crayfish population is threatened by competition with signal crayfish. Where this occurs white-clawed crayfish are typically eliminated within three or four years of populations mixing (Holdich, 2003). Surveys were undertaken in 2017 and identified the presence of white-clawed crayfish in the River Wensum (volume 6, annex 3.4: White-clawed Crayfish Survey).

8.6.3.5 Brook lamprey, bullhead and white-clawed crayfish are known to occur within the River Wensum SAC and are assumed to be present within the Hornsea Three onshore cable corridor.

Potential impacts — construction/decommissioning

Desmoulin's whorl snail — White-clawed crayfish — Brook lamprey — Bullhead

Permanent habitat loss

8.6.3.6 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, i.e. at the location of the onshore HVAC booster station, the onshore HVDC converter/HVAC substation and link boxes. It is proposed that direct impacts will be avoided by the application of HDD.

8.6.3.7 The Hornsea Three onshore cable corridor could result in the severance or impediment of ground water flows at the River Wensum, or Swannington Beck which flows into the River Wensum, with the potential to create drier ground conditions. Changes in hydrological conditions have the potential to impact the supporting habitats (i.e. permanently wet calcareous fens and marshes) of Desmoulin's whorl snail. Site visits have identified appropriate locations for the ducts and temporary works areas that are outside habitats with potential to support protected species. The direction of the Hornsea Three onshore cable corridor is approximately perpendicular to the direction of the waterways, i.e. in the same direction as the groundwater flows, and therefore groundwater flows will not likely be severed or impeded.

Conclusion

8.6.3.8 The proposed design measures (i.e. HDD or other trenchless technology) will avoid any permanent habitat loss within the River Wensum SAC for Desmoulin's whorl snail, white-clawed crayfish, brook lamprey and bullhead. Furthermore, no likely hydrological effects have been identified that may impact the water levels within the River Wensum that support white-clawed crayfish, brook lamprey and bullhead or adjacent wet habitats supporting Desmoulin's whorl snail. On this basis no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Temporary disturbance/damage

8.6.3.9 Temporary disturbance/damage will occur where natural or semi-natural habitats are subjected to activities that result in the removal of vegetation; the breaking up of the soil structure; and compaction by trackway, vehicles, personnel, equipment and stored materials.

8.6.3.10 As described above, it is proposed that direct impacts on the designated site will be avoided. Temporary compounds of at least 70 m x 70 m will be located at either end of the HDD crossing and as such will be located outside of the designated site.

8.6.3.11 Pre-construction studies will be carried out to identify sensitive habitats in the vicinity of large/sensitive watercourse crossing locations and plans developed for the establishment of associated construction compounds and works sites, to minimise potential impacts.

8.6.3.12 The locations of the haul roads will be within the Hornsea Three onshore cable corridor which will avoid designated sites.

8.6.3.13 Surveys have identified habitat of "good suitability" for Desmoulin's whorl snail along the River Wensum although three of four locations could not be surveyed for presence/likely absence (volume 6, annex 3.3: Desmoulin's Whorl Snail Survey). Where pre-construction studies identify the presence of Desmoulin's whorl snail in suitable habitat located within the Hornsea Three onshore cable corridor at the River Wensum, translocation of individual snails into adjacent retained habitat and habitat restoration will take place in accordance with best practice. This will allow re-colonisation once construction is complete. Given that the maximum design scenario involves a two-phase installation programme with a gap between phases, impacts of habitat loss from cable installation would be intermittent over this period and it may be necessary to relocate snails from watercourses up to two occasions. Exclusion of snails from the works area is not considered to be feasible or desirable as it would serve to isolate populations on either side of the Hornsea Three onshore cable corridor. Where no suitable habitat is found, construction will be unconstrained in relation to Desmoulin's whorl snail.

Conclusion

8.6.3.14 The proposed design measures will avoid any temporary habitat disturbance/damage within the River Wensum SAC that supports white-clawed crayfish, brook lamprey and bullhead and minimise effects to adjacent wet habitats supporting Desmoulin's whorl snail. On this basis no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Accidental pollution

8.6.3.15 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.6.3.16 Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP. Measures to be taken during HDD in relation to handling of bentonite and the requirement for plans to be produced for HDD beneath watercourses (to minimise the risk of pollution) are included in the Outline CoCP.

8.6.3.17 HDD is proposed at the River Wensum and Swannington Beck which is hydrologically connected to the River Wensum. The location of the start and end point of the HDD operation will be carefully selected to ensure that trenching up to the HDD locations will be sufficiently distant from the watercourse that the risk of run-off from trenching reaching the river will be minimised.

<u>Conclusion</u>

8.6.3.18 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the River Wensum SAC and adjacent wet habitats. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Invasive non-native species

8.6.3.19 Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonic*a are known to occur on the banks of the River Wensum (Natural England, 2014d). The presence of invasive non-native species can increase shade resulting in unsuitable conditions for Desmoulin's whorl snail (Killeen, 2003; Moorkens & Killeen, 2011) and potentially decrease water quality (Greenwood & Kuhn, 2014). The presence of signal crayfish in the River Wensum means that the presence of crayfish plague, which kills native white-clawed crayfish, is also likely to be present. To minimise the risk of spreading invasive species and crayfish plague to, from or within the River Wensum SAC it is proposed that works will be carried out in accordance with a biosecurity protocol documented in the Outline CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the Outline EMP and CoCP.

<u>Conclusion</u>

8.6.3.20 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the River Wensum SAC and adjacent wet habitats and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Potential impacts — operation/maintenance

<u>Desmoulin's whorl snail — White-clawed crayfish — Brook lamprey — Bullhead</u>

Accidental pollution

8.6.3.21 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works on access routes and at construction compounds and storage areas.

8.6.3.22 As described above, it is proposed that operational activities will take place at either end of the HDD cable section and outside of the River Wensum SAC. Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline EMP which accompanies the application. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

<u>Conclusion</u>

8.6.3.23 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the River Wensum SAC and adjacent wet habitats. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Invasive non-native species

8.6.3.24 Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonic*a are known to occur on the banks of the River Wensum (Natural England, 2014d). The presence of invasive non-native species can increase shade resulting in unsuitable conditions for Desmoulin's whorl snail (Killeen, 2003; Moorkens & Killeen, 2011) and potentially decrease water quality (Greenwood & Kuhn, 2014). The presence of signal crayfish in the River Wensum means that the presence of crayfish plague, which kills native white-clawed crayfish, is also likely to be present. To minimise the risk of spreading invasive species and crayfish plague to, from or within the River Wensum SAC it is proposed that works will be carried out in accordance with a biosecurity protocol documented in the EMP

<u>Conclusion</u>

8.6.3.25 The proposed application a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the River Wensum SAC and adjacent wet habitats. Therefore no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

8.6.4 North Norfolk Coast SAC

8.6.4.1 An introduction to the North Norfolk Coast SAC and its Conservation Objectives is presented in section 8.5.3.

Features screened into assessment

8.6.4.2 The features screened into the assessment are petalwort *Petalophyllum ralfsii* and otter *Lutra lutra* (Table 8.1).

Baseline

8.6.4.3 An assessment of LSE was based on the spatial overlap between the Hornsea Three onshore cable corridor and the North Norfolk Coast SAC including the location of the proposed onshore HVAC booster station and the onshore HVDC converter/HVAC substation. Otters have been recorded off Sheringham Road near Weybourne.

8.6.4.4 The permanent and temporary footprint of the Hornsea Three onshore cable elements as well as compounds and storage areas are spatially separated (0.32 km) from the North Norfolk Coast SAC, and therefore from any suitable sand dune habitat for petalwort within; the nearest sand dunes of any type being approximately 9 km west at Blakeney Point. The spatial separation between the Hornsea Three onshore cable corridor and the SAC is sufficiently large to exclude reasonably foreseeable impact pathways in relation to invasive non-native species and hydrological changes. Therefore, no adverse effect on site integrity will occur for construction/decommissioning and operation in respect of habitat loss and disturbance or damage to petalwort.

Potential impacts — construction/decommissioning

Otter

Permanent habitat loss

8.6.4.5 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, i.e. at the location of the onshore HVAC booster station, the onshore HVDC converter/HVAC substation and link boxes. Design measures incorporated into the project include the use of HDD under main rivers, and where possible under other watercourses supporting otters. Where HDD is to be undertaken beneath watercourses supporting otter, the launch pits will be located a minimum distance from the known otter holts and other identified resting places.

8.6.4.6 Where HDD is to be undertaken beneath watercourses supporting otter, consideration will be given to the location of launch pits and their relationship to watercourses. Appropriate buffers from construction and operational works will be established around sections of the watercourses that support otters. The launch pits will be located a minimum distance from known otter holts and other resting places. The width of these buffer zones will be developed in accordance with standard industry requirement and best practice guidance.

Conclusion

8.6.4.7 The proposed design and pre-construction measures will avoid permanent habitat loss in the North Norfolk Coast SAC and minimise habitat loss in functionally linked land associated with the otter population of the North Norfolk Coast SAC. Therefore no adverse effect on site integrity will occur with respect to the with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Temporary disturbance/damage

8.6.4.8 Temporary disturbance/damage will occur where natural or semi-natural habitats are subjected to activities that result in the removal of vegetation; the breaking up of the soil structure; and compaction by trackway, vehicles, personnel, equipment and stored materials.

8.6.4.9 An assessment of LSE was based on the spatial overlap between the Hornsea Three onshore cable corridor and the North Norfolk Coast SAC including the location of the proposed onshore HVAC booster station and the onshore HVDC converter/HVAC substation.

8.6.4.10 Otter have been protected by siting the Hornsea Three onshore cable corridor alignment to provide an appropriate buffer from construction and operational works. The width of these buffer zones will be developed in accordance with standard industry requirements and best practice guidance.

8.6.4.11 Where considered necessary by the ECoW, high visibility fencing will be erected between watercourses and adjacent riparian habitat and the works areas to prevent access by workers and heavy machinery, and also to prevent storage of equipment or materials within this zone. . Where night time works are necessary, lighting will be focussed on the works areas and away from watercourses. Lighting will be kept to a minimum where it might affect otter holts or other identified resting places.

8.6.4.12 HDD will be beneath watercourses and vehicle speeds will be limited whilst on site to minimise the potential for otters to be injured or killed by vehicles. HDD installation pits, other excavations and ducts will be covered overnight to prevent otters entering the areas, or a method of escape (such as a plank to act as a ladder) will be provided where such excavations cannot be covered or filled on a nightly basis.

Conclusion

8.6.4.13 The proposed design and construction measures will avoid any temporary habitat disturbance/damage within the North Norfolk Coast SAC and avoid and minimise any habitat disturbance/damage to any functionally linked land. Therefore no adverse effect on site integrity will occur with respect to the with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Habitat fragmentation

8.6.4.14 Habitat fragmentation will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of jointing pits. An assessment of LSE was based on the spatial overlap between the Hornsea Three onshore cable corridor and the North Norfolk Coast SAC including the location of the proposed onshore HVAC booster station and the onshore HVDC converter/HVAC substation. Otters have been recorded off Sheringham Road near Weybourne.

8.6.4.15 Design measures incorporated into the project include the use of HDD under all watercourses supporting otters. Where HDD is to be undertaken beneath watercourses supporting otter, consideration will be given to the location of launch pits and their relationship to watercourses. In this regard, appropriate buffers from construction and operational works will be established around sections of the watercourses that support otters, in accordance with standard industry requirement and best practice guidance.

<u>Conclusion</u>

8.6.4.16 The proposed design and pre-construction measures will avoid permanent habitat loss in the North Norfolk Coast SAC and in functionally linked land associated with the otter population of the North Norfolk Coast SAC. Furthermore, the construction measures will effectively minimise habitat fragmentation. Therefore, no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Accidental pollution

8.6.4.17 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.6.4.18 Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP. Measures to be taken during HDD in relation to handling of bentonite and the requirement for plans to be produced for HDD beneath watercourses (to minimise the risk of pollution) are included in the Outline CoCP.

<u>Conclusion</u>

8.6.4.19 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the North Norfolk Coast SAC. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Invasive non-native species

8.6.4.20 The introduction of invasive non-native species from contaminated construction equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonica* is known to be present in the Hornsea Three onshore cable corridor. To minimise the risk of spreading invasive species to, from or within the North Norfolk Coast SAC, works will be carried out in accordance with a biosecurity protocol as documented in the Outline CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the Outline EMP and CoCP.

<u>Conclusion</u>

8.6.4.21 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the North Norfolk Coast SAC and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore no adverse effect on site integrity will occur with respect to a change in extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting (physical, chemical or biological) processes on which the habitats rely.

Potential impacts — operation/maintenance

<u>Otter</u>

Accidental pollution

8.6.4.22 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.6.4.23 Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the EMP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

<u>Conclusion</u>

8.6.4.24 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the North Norfolk Coast SAC. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

8.7 Assessment of adverse effect on site integrity - ornithology

8.7.1.1 The screening exercise (Stage 1 of the HRA process) identified potential for LSEs on the terrestrial ornithology features of the sites listed in Table 8.1 and shown in Figure 8.1.

8.7.2 North Norfolk Coast SPA

Introduction

8.7.2.1 The North Norfolk Coast SPA encompasses much of the northern coastline of Norfolk in eastern England. It is a low-lying barrier coast that extends for 40 km from Holme to Kelling Hard and includes a great variety of coastal habitats. The main habitats – found along the whole coastline – include extensive intertidal sand- and mud-flats, saltmarshes, shingle and sand dunes, together with areas of freshwater grazing marsh and reedbed, which has developed in front of rising land. The site contains some of the best examples of saltmarsh in Europe. There are extensive deposits of shingle at Blakeney Point, and major sand dunes at Scolt Head. Extensive reedbeds are found at Brancaster, Cley and Titchwell. Maritime pasture is present at Cley and extensive areas of grazing marsh are present all along the coast. The grazing marsh at Holkham has a network of clear water dykes holding a rich diversity of aquatic plant species. The great diversity of high-quality freshwater, intertidal and marine habitats results in very large numbers of waterbirds occurring throughout the year. In summer, the site holds large breeding populations of waders, four species of terns, Bittern *Botaurus stellaris* and wetland raptors such as Marsh Harrier *Circus aeruginosus*. In winter, the coast is used by very large numbers of geese, sea-ducks, other ducks and waders. The coast is also of major importance for staging waterbirds in the spring and autumn migration periods. Breeding terns, particularly Sandwich Tern *Sterna sandvicensis*, and wintering sea-ducks regularly feed outside the SPA in adjacent coastal waters.

8.7.2.2 The site is located east of The Wash on the northern coastline of Norfolk, eastern England. The Hornsea Three onshore cable corridor and access routes are located 0.32 km from the North Norfolk Coast SPA with greater distances to permanent infrastructure (Figure 8.1). Therefore all its ornithological features have been screened into the assessment, aside from tern species and Mediterranean gulls. The North Norfolk Coast SPA colonies of qualifying breeding tern species and Mediterranean gull, are present at Scolt Head and Blakeney Point (Wilson *et al.,* 2014). These locations are over 5 km from the Hornsea Three onshore cable corridor for onshore works. As such there has been deemed, through the screening process, to be no potential for any impact pathway between the onshore elements of Hornsea Three as well as compounds, storage areas and access roads and the colony features.

Conservation Objectives

8.7.2.3 An AA requires the consideration of the impacts on the integrity of a European site, with regards to the site's structure and function and its Conservation Objectives. The Conservation Objectives of the North Norfolk Coast SAC are as follows:

With regard to the SPA and the individual species and/or assemblage 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 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.

Features screened into assessment

8.7.2.4 All qualifying features, except tern species and Mediterranean gull are screened into the assessment with respect to all potential impacts (Table 8.1).

Baseline

8.7.2.5 Wintering bird surveys have found that pink-footed geese use fields within and adjacent to the cable corridor between Weybourne and High Kelling (volume 6, annex 3.9: Onshore Ornithology – Wintering and Migratory Survey). These birds were, in general, present from late November until late January, on sugar beet fields. The vast majority of geese were focused in the coastal area of Weybourne where almost all fields that held sugar beet crop were being utilized at some point in the period. The largest field of sugar beet away from the Weybourne area was High Kelling (immediately south of Kelling Heath) which was utilized by 9,000 geese in early January 2017. No geese were recorded any further south than Hempstead despite sugar beet being available. The Hornsea Three onshore cable corridor runs through the western edge of the area used by the birds and also through another field immediately south of Kelling Heath.

8.7.2.6 The maximum count of pink-footed geese recorded during the surveys was 10,000. This represents 42% of the five-year peak mean count of this species (23,802) from the North Norfolk Coast SPA citation, or 4.45% of the wintering Eastern Greenland/Iceland/UK population.

8.7.2.7 The presence of a significant percentage of the total SPA population of pink-footed geese over a three month period suggests that the sugar beet fields should be considered as functionally linked habitat associated with the North Norfolk Coast SPA. Details of survey findings are provided in volume 6, annex 3.9: Onshore Ornithology – Wintering and Migratory Bird Survey.

8.7.2.8 Located over 500 m outside the Hornsea Three onshore cable corridor, a total of 17 qualifying / assemblage features were recorded at Kelling Quags, including 12 species not recorded elsewhere in the survey (little egret, Brent goose, shelduck, wigeon, shoveler, pintail, avocet, curlew, black-tailed godwit, redshank, snipe and dunlin). Wigeon was the most abundant species, peaking at 201 birds in late January 2017. Brent goose was recorded on three occasions and were observed to frequent both open water and arable land on the periphery of the Quags.

8.7.2.9 Outside of Kelling Quags, six qualifying / assemblage features were recorded (peak counts in parenthesis): European white-fronted goose (15), teal (6), gadwall (20), oystercatcher (6), lapwing (92) and golden plover (50) as well as records of both subspecies of bean goose (tundra *rossicus* (19) and taiga *fabalis* (2)).

8.7.2.10 No records of breeding qualifying features have been recorded within the Hornsea Three onshore cable corridor.

Potential impacts – construction/decommissioning

Pink-footed goose

Permanent habitat loss

8.7.2.1 Permanent habitat loss will occur where sugar beet fields (functionally linked land) are replaced with concrete and other manmade materials, i.e. at the location of link boxes. The total area of functionally linked sugar beet fields varies from year to year. Within the approximately 10,750 ha of the 1 km wide survey area encompassing fields with potential to be functionally linked if they are planted with sugar beet, only 77.9 ha were sugar beet fields in the winter of 2016/17 (31.7% of all sugar beet fields used) and 215.4 ha were sugar beet fields in the winter of 2017/18 (62.5% of all sugar beet fields used). These areas are not significant compared to the total sugar beet production along the North Norfolk Coast, e.g. 300 ha of sugar beet were harvested in the winter of 2017/18 from one just farm, Green Farm, Saxlingham, three miles west of Holt (Jones, 2017).The proposed design measures will avoid permanent habitat loss within functionally linked land associated with the North Norfolk Coast SPA. In most cases the onshore export cable will be buried to a depth of 1.2 m below ground level, with sections of the cable joined together at 9 m x 25 m jointing pits spaced at least 750 m apart with an associated 3 m x 3 m link box at each junction bay.

8.7.2.2 The associated habitat loss within the functionally linked land area between Weybourne and Kelling Heath, resulting from the man hole access to the jointing pits and link boxes, will be a very small fraction of the potential 10,749.5 ha of functionally linked land. The total area of permanent loss will not therefore be significant with respect to the total area of functionally linked land available.

8.7.2.3 Access to the link boxes, jointing pits and transition joint bays will be via existing roads, tracks and field gates, with the permission of the landowner. These visits will be made by light vehicles only.

Conclusions

8.7.2.4 The proposed route of the Hornsea Three onshore cable corridor will avoid permanent habitat loss within the North Norfolk Coast SPA site and the permanent footprint within the functional linked land area is not likely to be significant with respect to the total land area of functionally linked sugar beet land available. Therefore, no adverse effect on site integrity will occur with respect to the population and distribution of the pink-footed goose.

Temporary habitat loss

8.7.2.5 The sugar beet fields within the Hornsea Three onshore cable corridor becomes functionally linked only following the harvesting of sugar beet which makes available sugar beet tops and fragments to pink-footed geese. Temporary habitat loss will occur where sugar beet fields are subjected to activities that result in the removal of sugar beet or sugar beet tops from the ground; the covering of sugar beet by trackway, equipment and stored materials, or the use of temporary disturbance mitigation measusres if required (see below). The avoidance of designated sites, will avoid temporary habitat loss within the North Norfolk Coast SPA site however sugar beet, a biennial crop and food resource of pink-footed geese, will be temporarily lost where the construction footprint overlaps with the functionally linked sugar beet fields between Weybourne and Kelling Heath. The total area of sugar beet temporarily lost under the construction footprint cannot be quantified at this time because of the relatively short term cropping patterns within each farm. The temporary loss of sugar beet is not likely to be significant because pink-footed geese are highly mobile, responding to both harsh weather conditions and food availability (Mitchell & Hearn, 2004) and can have feeding ranges in the order of 21-69 km^2 (Giroux & Patterson, 1995).

Conclusions

8.7.2.6 No adverse effect on site integrity will occur with respect to the population and distribution of pink-footed goose because of the known mobility of this species in response to changes in food availability. As such this highly mobile species has the capacity to take advantage of food resources within a wide area including sugar beet fields beyond the area influenced by the Hornsea Three onshore cable corridor.

Temporary disturbance

8.7.2.7 The effects of noise, light and visual disturbance is likely to be measurable within 500 m of the works because of the type of construction (e.g. open trenching) activities being proposed within functionally linked sugar beet fields, i.e. narrow, linear working corridor using machinery which generates noise predominantly of a steady state rather than of an impulsive character. The majority of pink-footed geese were however outside this disturbance zone in both survey years.

8.7.2.8 Furthermore, within the approximately 10,750 ha of the 1 km wide survey area encompassing fields with potential to be functionally linked if they are planted with sugar beet, only 77.9 ha were sugar beet fields in the winter of 2016/17 (31.7% of all sugar beet fields used) and 215.4 ha were sugar beet fields in the winter of 2017/18 (62.5% of all sugar beet fields used). These areas are not significant compared to the total sugar beet production along the North Norfolk Coast, e.g. 300 ha of sugar beet were harvested in the winter of 2017/18 from one just farm, Green Farm, Saxlingham, three miles west of Holt (Jones, 2017).

8.7.2.9 Whilst there is “a lack of evidence that the feature [pink-footed goose] is being impacted by any anthropogenic activities” (Natural England, 2017d) an increased frequency of disturbance which may reduce the fitness of a significant group of birds at the time of construction cannot be excluded.

8.7.2.10 Therefore, if construction work on functionally linked sugar beet fields takes place between November and January inclusive, a pink-footed goose mitigation plan will be formulated and submitted to Natural England for approval.

8.7.2.11 The pink-footed goose mitigation plan will only apply to the construction phase of the onshore component (above MHWS) of the Hornsea Three onshore cable corridor. The mitigation plan is intended to enable construction works to be undertaken in a way that ensures that any disturbance of pink-footed geese is reduced to an acceptable level.

8.7.2.12 There are two steps to the plan:

- First, pre-construction surveys and investigations will be undertaken to determine the extent of disturbance likely to occur due to construction activities. This will include a survey of the distribution and abundance of pink-footed geese and the distribution of harvested sugar beet within those sections of the Hornsea Three onshore cable corridor (and a 500m disturbance buffer) likely to be affected during the winter season within which works will take place; and
- Second, if required, measures to reduce disturbance or provide alternative foraging habitat will be implemented sufficient to reduce the effects of disturbance to an acceptable level. The measures will be proportionate to the predicted impact at the time of construction and will be effective and agreed with Natural England prior to implementation.

8.7.2.13 Mitigation measures will be implemented between 1 November and 31 January only and the mitigation measures, if required, will be monitored to ensure effectiveness.

8.7.2.14 To minimise the risk of disturbance at all times and locations, noise reduction measure from industry best practice guidance (BS 5228-1:2009+A1:2014 ‘Code of practice for noise and vibration control on construction and open sites’) will be set out in the Outline CoCP and EMP.

8.7.2.15 Where outdoor lighting is required, lighting units will be directional, fully shielded if not LED lighting and in all cases directed only on to the construction works area. Principles of the lighting strategy are contained in the Outline CoCP which accompanies the application.

<u>Conclusion</u>

8.7.2.16 The Hornsea Three onshore cable corridor is approximately 0.32 km east of the North Norfolk Coast SPA and therefore disturbance within the designated site is not likely to be significant because of the spatial separation.

8.7.2.17 If construction works take place outside November and January inclusive, there will be no disturbance impact pathway on pink-footed goose and there will be no adverse effect on site integrity.

8.7.2.18 If construction works take place on functionally linked sugar beet fields between November and January inclusive, the application of a pink-footed goose mitigation plan, together with industry best practice guidance in respect of light and noise mitigation measures, will avoid or minimise the risk of disturbance to functionally linked sugar beet fields used for foraging.

8.7.2.19 Therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features.

Accidental pollution

8.7.2.20 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.7.2.21 Details of measures relating to pollution prevention will be described in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

<u>Conclusion</u>

8.7.2.22 The proposed design measures will avoid accidental pollution and the application pollution control measures will minimise the residual risk within the functionally linked sugar beet fields. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features, the physical, chemical or biological supporting processes associated with the site and which help to support and sustain its qualifying features and the extent, distribution, structure and function of their supporting habitats. and the extent, distribution, structure and function of their supporting habitats.

Invasive non-native species

8.7.2.23 The introduction of invasive non-native species from contaminated construction equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. To minimise the risk of spreading invasive to, from or within the functionally linked sugar beet fields it is proposed that works will be carried out in accordance with a biosecurity protocol as documented in the Outline CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the Outline EMP and CoCP.

Conclusion

8.7.2.24 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the functionally linked sugar beet fields and adjacent wet habitats and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore, no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features, the supporting process and the extent, distribution, structure and function of their supporting habitats.

Potential impacts – operation and maintenance

Temporary habitat loss and disturbance

8.7.2.25 Temporary habitat loss will occur where sugar beet fields are subjected to activities that result in the removal of sugar beet or sugar beet tops from the ground; the covering of sugar beet by trackway, equipment and stored materials, or the use of methods to avoid temporary disturbance to displace birds (see below). Operational maintenance of the Hornsea Three onshore cable corridor will take the form of inspections via the link boxes and repairs to the cable will be conducted from the relevant jointing bays and pulled between them. Access to the link boxes, jointing pits and transition joint bays will be via existing roads, tracks and field gates, with the permission of the landowner. These visits will be made by light vehicles only. As described above, it is proposed that direct impacts on the designated site will be avoided and therefore operational activities will take place outside of the North Norfolk Coast SPA.

8.7.2.26 On functionally linked land, disturbance is likely to occur where work is carried out on the 9.3 km of the Hornsea Three onshore cable corridor from landfall during the period November to January inclusive. Where emergency works are required within the period November to January inclusive, the Outline EMP will include the method statement to minimise any temporary disturbance.

Conclusion

8.7.2.27 The proposed design and operational measures will avoid any temporary habitat loss and disturbance within the North Norfolk Coast SPA site and avoid or minimise temporary habitat loss and disturbance in functionally linked sugar beet fields used for foraging. Taking into account the proposed mitigation and the fact that the majority of pink-footed geese were recorded more than 500m from the Hornsea Three onshore cable corridor, no adverse effect on site integrity will occur with respect to the population and distribution of pink-footed goose.

Accidental pollution

8.7.2.28 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.7.2.29 Details of the pollution control measures proposed are provided in volume 3, chapter 2: Hydrology and Flood Risk and in the EMP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

8.7.2.30 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the functionally linked sugar beet fields. The employment of an ECoW will ensure compliance with the Outline EMP and therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features, the supporting process and the extent, distribution, structure and function of their supporting habitats.

8.7.3 North Norfolk Coast Ramsar

Introduction

8.7.3.1 The North Norfolk Coast Ramsar Site is located in the same geographical area as the North Norfolk Coast SAC and SPA. The site extends for 40 km from Holme to Kelling Hard and encompasses a variety of habitats including intertidal sands and muds, saltmarshes, shingle and sand dunes, together with areas of land-claimed freshwater grazing marsh and reedbed, which is developed in front of rising land. Both freshwater and marine habitats support internationally important numbers of wildfowl in winter and several nationally rare breeding birds. The sandflats, sand dune, saltmarsh, shingle and saline lagoons habitats are of international importance for their fauna, flora and geomorphology.

8.7.3.2 The Hornsea Three onshore cable corridor and access routes are located 0.32 km from the North Norfolk Coast Ramsar site with greater distances to permanent infrastructure (Figure 8.1). The functionally linked land relate to the Ramsar site has the same spatial extent as the SPA functionally linked land.

Conservation Objectives

8.7.3.3 In accordance with Article 3.1 of the Ramsar Convention, Contracting Parties commit to the wise use of wetlands and in particular to maintain the ecological character of wetlands, i.e. the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

8.7.3.4 As the provisions on the Habitats Regulations relating to Habitat Regulations Assessments (HRAs) extend to Ramsar sites, Natural England considers the Conservation Advice packages for the overlapping European site designations to be, in most cases, sufficient to support the management of the Ramsar interests. As such the Conservation Objectives of the North Norfolk Coast SPA are applied to the Ramsar site (see 8.7.1.1).

Features screened into assessment

All ornithological qualifying features, except tern species (see offshore ornithology section above) are screened into the assessment with respect to all potential impacts (Table 8.1).

Baseline

8.7.3.5 Taking into account both the complete spatial overlap and the commonality of the qualifying features between the North Norfolk Coast SPA and North Norfolk Coast Ramsar site, the baseline is described above in section 8.7.1.1.

Potential impacts – construction/decommissioning

Pink-footed goose

Permanent habitat loss

8.7.3.6 Permanent habitat loss will occur where sugar beet fields (functionally linked land) are replaced with concrete and other manmade materials, i.e. at the location of link boxes. The total area of functionally linked sugar beet fields varies from year to year. Within the 10,749.5 ha of the one kilometre wide survey area encompassing fields with potential to be functionally linked if they are planted with sugar beet, only 77.9 ha were sugar beet fields in the winter of 2016/17 (31.7% of all sugar beet fields used) and 215.4 ha were sugar beet fields in the winter of 2017/18 (62.5% of all sugar beet fields used). These areas are not significant compared to the total sugar beet production along the North Norfolk Coast, e.g. 300 ha of sugar beet were harvested in the winter of 2017/18 from one just farm, Green Farm, Saxlingham, three miles west of Holt (Jones, 2017).The proposed design measures will avoid permanent habitat loss within the North Norfolk Coast SPA . In most cases the onshore export cable will be buried to a depth of 1.2 m below ground level, with sections of the cable joined together at 9 m x 25 m jointing pits spaced at least 750 m apart with an associated 3 m x 3 m link box at each junction bay.

8.7.3.7 The associated habitat loss within the functionally linked land area between Weybourne and Kelling Heath, resulting from the man hole access to the jointing pits and link boxes, will be a very small fraction of the potential 10,749.5 ha of functionally linked land. The total area of permanent loss will not therefore be significant with respect to the total area of functionally linked land available.

8.7.3.8 Access to the link boxes, jointing pits and transition joint bays will be via existing roads, tracks and field gates, with the permission of the landowner. These visits will be made by light vehicles only.

Conclusions

8.7.3.9 The proposed route of the Hornsea Three onshore cable corridor will avoid permanent habitat loss within the North Norfolk Coast Ramsar site and the permanent footprint within the functional linked land area is not likely to be significant with respect to the total land area of functionally linked sugar beet land available. Therefore no adverse effect on site integrity will occur with respect to the population and distribution of the pink-footed goose.

Temporary habitat loss

8.7.3.10 The sugar beet fields within the Hornsea Three onshore cable corridor becomes functionally linked only following the harvesting of sugar beet which makes available sugar beet tops and fragments to pink-footed geese. Temporary habitat loss will occur where sugar beet fields are subjected to activities that result in the removal of sugar beet or sugar beet tops from the ground; the covering of sugar beet by trackway, equipment and stored materials, or the use of temporary disturbance mitigation measusres if required (see below). The avoidance of designated sites, will avoid temporary habitat loss within the North Norfolk Coast Ramsar site however sugar beet, a biennial crop and food resource of pink-footed geese, will be temporarily lost where the construction footprint overlaps with the functionally linked sugar beet fields between Weybourne and Kelling Heath. The total area of sugar beet temporarily lost under the construction footprint cannot be quantified at this time because of the relatively short term cropping patterns within each farm. The temporary loss of sugar beet is not likely to be significant because pink-footed geese are highly mobile, responding to both harsh weather conditions and food availability (Mitchell & Hearn, 2004) and can have feeding ranges in the order of 21-69 km^2 (Giroux & Patterson, 1995).

Conclusions

8.7.3.11 No adverse effect on site integrity will occur with respect to the population and distribution of pink-footed goose because of the known mobility of this species in response to changes in food availability. As such this highly mobile species has the capacity to take advantage of food resources within a wide area including sugar beet fields beyond the area influenced by the Hornsea Three onshore cable corridor.

Temporary disturbance

8.7.3.12 The effects of noise, light and visual disturbance is likely to be measurable within 500 m of the works because of the type of construction (e.g. open trenching) activities being proposed within functionally linked sugar beet fields, i.e. narrow, linear working corridor using machinery which generates noise predominantly of a steady state rather than of an impulsive character. The majority of pink-footed geese were however outside this disturbance zone in both survey years.

8.7.3.13 Furthermore, within the approximately 10,750 ha of the 1 km wide survey area encompassing fields with potential to be functionally linked if they are planted with sugar beet, only 77.9 ha were sugar beet fields in the winter of 2016/17 (31.7% of all sugar beet fields used) and 215.4 ha were sugar beet fields in the winter of 2017/18 (62.5% of all sugar beet fields used). These areas are not significant compared to the total sugar beet production along the North Norfolk Coast, e.g. 300 ha of sugar beet were harvested in the winter of 2017/18 from one just farm, Green Farm, Saxlingham, three miles west of Holt (Jones, 2017).

8.7.3.14 Whilst there is "a lack of evidence that the feature [pink-footed goose] is being impacted by any anthropogenic activities" (Natural England, 2017d) an increased frequency of disturbance which may reduction the fitness of a significant group of birds at the time of construction cannot be excluded.

8.7.3.15 Therefore, if construction work on functionally linked sugar beet fields takes place between November and January inclusive, a pink-footed goose mitigation plan will be formulated and submitted to Natural England for approval.

8.7.3.16 The pink-footed goose mitigation plan will only apply to the construction phase of the onshore component (above MHWS) of the Hornsea Three export cable corridor. The mitigation plan is intended to enable construction works to be undertaken in a way that ensures that any disturbance of pink-footed geese is reduced to an acceptable level.

8.7.3.17 There are two steps to the plan:

- First, pre-construction surveys and investigations will be undertaken to determine the extent of disturbance likely to occur due to construction activities. This will include a survey of the distribution and abundance of pink-footed geese and the distribution of harvested sugar beet within those sections of the Hornsea Three onshore cable corridor (and a 500m disturbance buffer) likely to be affected during the winter season within which works will take place; and
- Second, if required, measures to reduce disturbance or provide alternative foraging habitat will be implemented sufficient to reduce the effects of disturbance to an acceptable level. The measures will be proportionate to the predicted impact at the time of construction and will be effective and agreed with Natural England prior to implementation.

8.7.3.18 Mitigation measures will be implemented between 1 November and 31 January only and the mitigation measures, if required, will be monitored to ensure effectiveness.

8.7.3.19 To minimise the risk of disturbance at all times and locations, noise reduction measure from industry best practice guidance (BS 5228-1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites') will be set out in the Outline CoCP and EMP.

8.7.3.20 Where outdoor lighting is required, lighting units will be directional, fully shielded if not LED lighting and in all cases directed only on to the construction works area. Details of lighting will be contained in the Outline CoCP.

Conclusion

8.7.3.21 The Hornsea Three onshore cable corridor is approximately 0.32 km east of the North Norfolk Coast Ramsar and therefore disturbance within the designated site is not likely to be significant because of the spatial separation.

8.7.3.22 If construction works take place outside November and January inclusive, there will be no disturbance impact pathway on pink-footed goose and there will be no adverse effect on site integrity.

8.7.3.23 If construction works take place on functionally linked sugar beet fields between November and January inclusive, the application of a pink-footed goose mitigation plan, developed with and approved by Natural England, together with industry best practice guidance in respect of light and noise mitigation measures, will avoid or minimise the risk of disturbance to functionally linked sugar beet fields used for foraging.

8.7.3.24 Therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features.

Accidental pollution

8.7.3.25 The use and storage of fuels, concrete and other biologically harmful substances on the construction site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.7.3.26 Details of measures relating to pollution prevention will be described in volume 3, chapter 2: Hydrology and Flood Risk and in the Outline CoCP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

8.7.3.27 The proposed design measures will avoid accidental pollution and the application pollution control measures will minimise the residual risk within the functionally linked sugar beet fields. The employment of an ECoW will ensure compliance with the Outline EMP and CoCP and therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features, the supporting process and the extent, distribution, structure and function of their supporting habitats.

Invasive non-native species

8.7.3.28 The introduction of invasive non-native species from contaminated construction equipment, vehicles and imported materials can result in the replacement of native species and modification to habitat structure and function. To minimise the risk of spreading invasive to, from or within the functionally linked sugar beet fields it is proposed that works will be carried out in accordance with a biosecurity protocol documented in the Outline CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the Outline EMP and CoCP.

Conclusion

8.7.3.29 The proposed application of a biosecurity protocol will minimise the risk of introducing or spreading invasive non-native plant or animal species within the functionally linked sugar beet fields and adjacent wet habitats and the employment of an ECoW will ensure compliance with the Outline EMP and CoCP. Therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features, the supporting process and the extent, distribution, structure and function of their supporting habitats.

Potential impacts – operation and maintenance

Pink-footed goose

Temporary habitat loss and disturbance

8.7.3.30 Temporary habitat loss will occur where sugar beet fields are subjected to activities that result in the removal of sugar beet or sugar beet tops from the ground; the covering of sugar beet by trackway, equipment and stored materials, or the use of methods to avoid temporary disturbance to displace birds (see below). Operational maintenance of the Hornsea Three onshore cable corridor will take the form of inspections via the link boxes and repairs to the cable will be conducted from the relevant jointing bays and pulled between them. Access to the link boxes, jointing pits and transition joint bays will be via existing roads, tracks and field gates, with the permission of the landowner. These visits will be made by light vehicles only. As described above, it is proposed that direct impacts on the designated site will be avoided and therefore operational activities will take place outside of the North Norfolk Coast Ramsar.

8.7.3.31 On functionally linked land, disturbance is likely to occur where work is carried out on the 9.3 km of the Hornsea Three onshore cable corridor from landfall during the period November to January inclusive. Where emergency works are required within the period November to January inclusive, the Outline EMP will include the method statement to minimise any temporary disturbance.

Conclusion

8.7.3.32 The proposed design and operational measures will avoid any temporary habitat loss and disturbance within the North Norfolk Coast Ramsar site and avoid or minimise temporary habitat loss and disturbance in functionally linked sugar beet fields used for foraging. Taking into account the proposed mitigation and the fact that the majority of pink-footed geese were recorded more than 500m from the Hornsea Three onshore cable corridor, no adverse effect on site integrity will occur with respect to the population and distribution of pink-footed goose.

Accidental pollution

8.7.3.33 The use and storage of fuels, concrete and other biologically harmful substances on the operational site has the potential to result in habitat damage if accidentally released into the environment. This potential impact is likely to arise at the point of works, on access routes and at compounds and storage areas.

8.7.3.34 Details of the pollution control measures proposed are provided in Environmental Statement volume 3, chapter 2: Hydrology and Flood Risk and in the PEMMP. Measures will include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

8.7.3.35 The proposed design measures will avoid accidental pollution and the application of pollution control measures will minimise the residual risk within the functionally linked sugar beet fields. The employment of an ECoW will ensure compliance with the Outline EMP and therefore no adverse effect on site integrity will occur with respect to the population and distribution of the qualifying features and the supporting processes associated with the site.

8.8 In combination assessment methodology

8.8.1 Screening of other projects, plans and activities into the in combination assessment

8.8.1.1 The in combination assessment considers the impact associated with Hornsea Three together with other projects and plans, also referred to as 'cumulative effects'. The projects and plans selected as relevant to the assessments presented within this section are based upon the results of a screening exercise undertaken (see Environmental Statement volume 4, annex 5.2: Cumulative Effects Screening Matrix and Environmental Statement volume 4, annex 5.3: Location of Cumulative Schemes). Each project on the CEA long list has been considered on a case by case basis for scoping in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

8.8.1.2 In undertaking the in combination assessment for Hornsea Three, it is important to bear in mind that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Hornsea Three. For example, relevant projects and plans that are already under construction are likely to contribute to an in-combination effect with Hornsea Three (providing effect or spatial pathways exist), whereas projects and plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors. For this reason, all relevant projects and plans considered cumulatively alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the CEA to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each Tier in the decision-making process when considering the potential cumulative impact associated with Hornsea Three (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2). An explanation of each tier is included below:

- Tier 1: Hornsea Three considered alongside:
  - Other project/plans currently under construction; and/or

    - Those with consent, and, where applicable (i.e. for low carbon electricity generation projects), that have been awarded a Contract for Difference (CFD) but have not yet been implemented; and/or
    - Those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact.
- Tier 2: All projects/plans considered in Tier 1, as well as:
    - Those project/plans that have consent but, where relevant (i.e. for low carbon electricity generation projects) have no CFD; and/or
    - Submitted but not yet determined.

8.8.1.3 Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects and the adopted development plan including supplementary planning documents are the most relevant sources of information, along with information from the relevant planning authorities regarding planned major works being consulted upon, but not yet the subject of a consent application). Specifically, this Tier includes all projects where the developer has advised PINS in writing that they intend to submit an application in the future, those projects where a Scoping Report is available and/or those projects which have published a PEIR. The specific projects scoped into this in combination assessment and the Tiers into which these have been allocated, are outlined in Table 8.2. The projects included as operational in this assessment have been commissioned since the baseline studies for this project were undertaken and as such were excluded from the baseline assessment.

8.8.2 Maximum design scenarios

8.8.2.1 The maximum design scenarios identified in Table 8.2 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The in combination impact presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (Environmental Statement volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, in order to inform a 'maximum design scenario' (see Environmental Statement volume 4, annex 5.2: Cumulative Effects Screening Matrix and Environmental Statement volume 4, annex 5.3: Location of Cumulative Schemes). Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

8.8.2.2 None of the in combination developments are proposed in the vicinity of designated sites or main watercourses that are potentially affected by Hornsea Three. Therefore, the potential for cumulative impacts is restricted to habitat loss or disturbance to species as a result of cable installation or decommissioning (in the event that the construction or decommissioning phases overlap with that of Hornsea Three, or if operational maintenance works overlap with construction of other developments). In these scenarios there would be a greater potential for displacement or disturbance for species.

8.8.2.3 Therefore, potential cumulative impacts from impacts arising from HDD operations, construction of access tracks, temporary compounds and permanent infrastructure have been scoped out of the in combination assessment.

8.8.2.4 At present there is insufficient information on the timing of construction for the developments listed in Table 8.3 to be able to determine whether overlap with cabling works would occur. The maximum duration of construction for the Hornsea Three onshore cable corridor would be 5.5 years incorporating two phases (assuming a three-year gap between the two phases). The work in each phase is expected to progress along the Hornsea Three onshore cable corridor with a typical active construction works duration of three months at any particular location. There are therefore two potential windows for overlap with construction of developments close to the onshore cable corridor. No Tier 1 projects have been identified and, therefore, only Tier 2 and Tier 3 projects have been included in the assessment.

8.8.2.5 Given the length of time that will elapse between now and the decommissioning phase, it is not known if there are any potential for cumulative impacts from developments close to the Hornsea Three onshore cable corridor. The potential impacts during this phase have been assumed to be similar to (and not worse than) those predicted during the construction for all receptors. It is therefore assumed that decommissioning overlap be similar to (and not worse than) the overlap predicted for construction.

Table 8.2: Maximum design scenario considered for the assessment of potential in combination impacts on ecology and nature conservation.

Potential impact	Maximum design scenario	Justification
Construction phase		
Potential for open cut trenching and installation of cables and associated temporary construction compounds to habitat loss and/or severance for a number of species	Tier 2 • 2014/2611; • 2011/1804/O; • 2015/1697; • 2012/1836; • 2013/0092; • 20151644; • 20170789; • C/7/2014/7030; and • 20170052. Tier 3 • EN010079.	Outcome of the CEA will be greatest when the greatest number of other schemes, present or planned, are considered.
Operation and Maintenance phase		
Potential for operation to result in low-level visual disturbance, and noise and vibration disturbance of habitats and wildlife during routine maintenance operations	Tier 2 • 2014/2611; • 2011/1804/O; • 2015/1697; • 2012/1836; • 2013/0092; • 20151644; • 20170789; • C/7/2014/7030; and • 20170052. Tier 3 • EN010079.	Outcome of the CEA will be greatest when the greatest number of other schemes, present or planned, are considered.
Decommissioning phase		
Potential for decommissioning of cables to affect species	Tier 2 • 2014/2611; • 2011/1804/O; • 2015/1697; • 2012/1836; • 2013/0092; • 20151644; • 20170789; • C/7/2014/7030; and • 20170052. Tier 3 • EN010079.	Outcome of the CEA will be greatest when the greatest number of other schemes, present or planned, are considered.

8.9 Assessment of potential effect on site integrity in combination with other plans and projects

8.9.1.1 The assessment has considered the potential impacts of Hornsea Three during construction, operation and maintenance and decommissioning, in combination with other relevant plans and projects with respect to the site's Conservation Objectives. Based on the spatial proximity between the Hornsea Three onshore cable corridor, including the location of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation, and the European sites, only the export cable and associated access infrastructure are located near enough in combination impact pathways to exist.

8.9.1.2 All Tier 2 residential and commercial developments are located south of the A47 with no reasonably foreseeable in combination impact pathway to any European site when taking into account their location downstream of the nearest European site (River Wensum) screened into this assessment.

8.9.1.3 The proposed Northern Distributor Road is due to be completed in March 2018 and therefore there will be no overlap in construction periods. During operation of the NDR the potential for sediment ingress to result in an adverse effect on the integrity of the River Wensum was identified. The Hornsea Three onshore cable corridor will employ HDD to pass under the River Wensum SAC and Swannington Beck and therefore any sediment ingress as a result of Hornsea Three will be avoided during construction and operation. An in combination impact pathway to the River Wensum is therefore not reasonably foreseeable.

8.9.1.4 In respect of Tier 3 developments, an in combination impact pathway exists between Hornsea Three and Norfolk Vanguard at Booton Common where the two cables routes are roughly perpendicular.

8.9.1.5 The potential for in combination effects arises in the event that the two cabling operations coincide. The Norfolk Vanguard application is expected to be submitted to the Planning Inspectorate in 2018. Assuming that the application proceeds through the planning system at a similar rate to Hornsea Three, there is potential for an overlap of the construction periods in relation to the onshore cabling works.

8.9.1.6 As a result of refinements to the design since potential impacts were screened (Annex 1: HRA Screening Report), Hornsea Three will avoid any direct impact to Booton Common. The results of surveys undertaken in 2017 identified the likely absence of Desmoulin's whorl snail and narrow-mouthed whorl snail from the Hornsea Three onshore cable corridor.

8.9.1.7 Therefore, no in combination adverse effect on the integrity on any European or Ramsar site screened into this assessment can be concluded with respect to the extent and population of narrow-mouthed and Desmoulin's whorl snails and the extent, distribution, structure and function of their supporting habitats.

Table 8.3: List of other projects and plans (with planning application reference) considered within the in combination assessment.

Tier	Phase	Project/Plan	Distance from Hornsea Three	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
2	Construction and Maintenance/ Decommissioning	C/7/2014/7030	0 m	(I) For a southern extension to Mangreen Quarry and ancillary works with progressive restoration to agriculture and nature conservation by the importation of inert restoration materials; (II) Retention of existing consented facilities at Mangreen Quarry; (III) Establishment of crossing point over Mangreen Lane; and (IV) Proposed variation to approved restoration scheme at Mangreen Quarry. Approved 02 October 2015	2019-2024	Yes	Yes
	Construction and Maintenance/ Decommissioning	2013/0092	7 m	Outline application for up to 20 residential units and associated highways works with all matters reserved. Approved 20 March 2014	2020-2028	Yes	Yes
	Construction and Maintenance/ Decommissioning	2014/2611	30 m	The erection of 890 dwellings; the creation of a village heart to feature an extended primary school, a new village hall, a retail store and areas of public open space; the relocation and increased capacity of the allotments; and associated infrastructure including public open space and highway works. Approved 01 November 2016	2018-2028	Yes	Yes
	Construction and Maintenance/ Decommissioning	20170789	52 m	Erection of Grain Store (Revised Proposal) Approved 19 July 2017	2020	Yes	Yes
	Construction and Maintenance/ Decommissioning	2011/1804/O	303 m	Residential led mixed use development of 1196 dwellings and associated uses including Primary School, Local Services (up to 1,850 sq. mtrs (GIA) of A1, A2, A3, A4, A5, D1 & B1 uses) comprising shops, small business units, community facilities/doctors' surgeries, sports pitches, recreational space, equipped areas of play and informal recreation spaces. Extension to Thickthorn Park and Ride including new dedicated slip road from A11. Approved 22 July 2013	2017-2026	Yes	Yes
	Construction and Maintenance/ Decommissioning	20151644	310 m	Demolition of 4 Existing Units and Development of 10 Residential Units, Together with Associated Access (Outline) Approved 10 June 2016	2022-2023	Yes	Yes
	Construction and Maintenance/ Decommissioning	2015/1697	312 m	Erection of 27 dwellings, access, roads, open space, parking areas and associated works. Approved 27 June 2016	2019-2020	Yes	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
	Construction and Maintenance/ Decommissioning	20170052	325 m	Greater Norwich Food Enterprise Zone Approved 31 October 2017	Not known	Yes	Yes
	Construction and Maintenance/ Decommissioning	2012/1836	338 m	Outline application for residential development (20 Dwellings) and associated infrastructure works, including highway improvement works at the Mill Road/School Lane/Burnthouse Lane junction. Approved 29 April 2014	2018-2020	Yes	Yes
	Construction and Maintenance/ Decommissioning	2016/1303	699 m	Construction of a new field trials building with associated services yard and on-site parking and alterations to existing agricultural building. Approved 05 September 2016	2020	Yes	Yes
3	Construction and Maintenance/ Decommissioning	EN010079	0 m	Norfolk Vanguard is a proposed offshore windfarm with an approximate capacity of 1800 MW off the coast of Norfolk. Pre-application stage PEIR October 2017	2020-2024	Yes	Yes

8.10 Summary

8.10.1.1 A summary of the conclusions of adverse effect on the integrity of the sites considered within in this section of the RIAA is provided in Table 8.4.

Table 8.4: Summary of conclusions

Site	Feature	Project phase	Effect	Conclusion Project alone	Conclusion project in combination with other plans and projects
Annex I habitats					
Norfolk Valley Fens SAC	• Alkaline fens (Calcium-rich springwater-fed fens) • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*). (Alder woodland on floodplains) • Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. (Calcium-rich fen dominated by great fen sedge (saw sedge)) • European dry heaths • Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*). (Purple moor-grass meadows) • Northern Atlantic wet heaths with *Erica tetralix* (Wet heathland with cross-leaved heath) • Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) (Dry grasslands and scrublands on chalk or limestone)	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
Wensum River SAC	• Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; Rivers with floating vegetation often dominated by water-crowfoot	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
North Norfolk Coast SAC	• Coastal lagoons • Fixed dunes with herbaceous vegetation (grey dunes). (Dune grassland) • Embryonic shifting dunes • Humid dune slacks • Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*). (Mediterranean saltmarsh scrub) • Perennial vegetation of stony banks. (Coastal shingle vegetation outside the reach of waves) • Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes). (Shifting dunes with marram).	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
North Norfolk Coast Ramsar Site	• **Ramsar criterion 1:** • The site is one of the largest expanses of undeveloped coastal habitat of its type in Europe. It is a particularly good example of a marshland coast with intertidal sand and mud, saltmarshes, shingle banks and sand dunes. There are a series of brackish-water lagoons and extensive areas of freshwater grazing marsh and reed beds. • **Ramsar criterion 2:** • Supports at least three British Red Data Book and nine nationally scarce vascular plants, one British Red Data Book lichen and 38 British Red Data Book invertebrates.	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
Annex II species					
Norfolk Valley Fens SAC	• Narrow-mouthed whorl snail *Vertigo angustior* • Desmoulin's whorl snail *Vertigo moulinsiana*	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted

Site	Feature	Project phase	Effect	Conclusion Project alone	Conclusion project in combination with other plans and projects
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
Wensum River SAC	• Desmoulin`s whorl snail *Vertigo moulinsiana* • White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes* • Brook lamprey *Lampetra planeri* • Bullhead *Cottus gobio*	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
North Norfolk Coast SAC	• Otter *Lutra lutra* • Petalwort *Petalophyllum ralfsii*	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted

Site	Feature	Project phase	Effect	Conclusion Project alone	Conclusion project in combination with other plans and projects
• ***Ornithology***					
North Norfolk Coast SPA	• **Annex 1 species (qualified under Article 4.1):** • During the breeding season: • Avocet *Recurvirostra avosetta,* • Bittern *Botaurus stellaris* • Marsh harrier *Circus aeruginosus* • Over winter: • Avocet *Recurvirostra avosetta* • Bar-tailed Godwit *Limosa lapponica* • Bittern *Botaurus stellaris* • Golden Plover *Pluvialis apricaria* • Hen Harrier *Circus cyaneus* • Ruff *Philomachus pugnax* • **Migratory species (qualified under Article 4.2):** • During the breeding season: • Redshank *Tringa totanus* • Ringed Plover *Charadrius hiaticula* • On passage: • Ringed Plover *Charadrius hiaticula* • Over-winter:	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Habitat fragmentation • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted

Site	Feature	Project phase	Effect	Conclusion Project alone	Conclusion project in combination with other plans and projects
	• Dark-bellied Brent Goose *Branta bernicla bernicla* • Knot *Calidris canutus* • Pink-footed Goose *Anser brachyrhynchus* • Pintail *Anas acuta* • Redshank *Tringa totanus* • Wigeon *Anas penelope* • **Waterfowl assemblage (qualified under Article 4.2):** • Over winter, the area regularly supports 91,249 individual waterfowl (5 year peak mean 1991/2 - 1995/6) including: Shelduck *Tadorna tadorna*, Avocet Golden Plover , Ruff , Bar-tailed Godwit *Limosa lapponica*, Pink-footed Goose *Anser brachyrhynchus*, Dark-bellied Brent *Goose Branta bernicla bernicla*, Wigeon *Anas penelope*, Pintail *Anas acuta*, Knot *Calidris canutus,* Redshank *Tringa totanus*, Bittern *Botaurus stellaris*, White-fronted Goose *Anser albifrons albifrons*, Dunlin *Calidris alpina alpina,* Gadwall *Anas strepera*, Teal *Anas crecca*, Shoveler *Anas clypeata*, Common Scoter *Melanitta nigra*, Velvet Scoter *Melanitta fusca*, Oystercatcher *Haematopus ostralegus*, Ringed Plover *Charadrius hiaticula*, Grey Plover *Pluvialis squatarola*, Lapwing *Vanellus vanellus*, Sanderling *Calidris alba*, Cormorant *Phalacrocorax carbo.*	Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
North Norfolk Coast Ramsar Site	• **Ramsar criterion 5:** • Species with peak counts in winter: 98462 waterfowl (5 year peak mean 1998/99-2002/2003).	Construction/ Decommissioning	• Permanent habitat loss • Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
	• **Ramsar criterion 6:** • On passage: • Knot *Calidris canutus* • Over-winter: • Dark-bellied Brent Goose *Branta bernicla bernicla* • Pink-footed Goose *Anser brachyrhynchus* • Pintail *Anas acuta* • Wigeon *Anas penelope*	Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted

9. References

ABPmer Ltd (2005). Sand banks, sand transport and offshore wind farms. Report for DTI.

ABPmer (2010) Area 506 Dredging Licence Application: Coastal Impact Study. DEME Building Materials Ltd. September 2010, R.1677, 51pp.

ABPmer (2013) Application Area 483 and 484 Plume Study. For Emu. Report R.2080.

Adams, T.P., Miller, R.G., Aleynik, D. and Burrows, M.T. (2014) Offshore marine renewable energy devices as stepping stones across biogeographical boundaries. Journal of Applied Ecology, 51, 33-338.

APEM (2013) Analysis of invertebrate communities and sediment composition of the subtidal sandbanks of The Wash and North Norfolk Coast. APEM Scientific Report no 412577.

Balmer, D. E., Gillings, S., Caffrey, B. J., Swann, R. L.,Downie, I. S., & Fuller, R. J. 2013. Bird Atlas 2007–11: the breeding and wintering birds of Britain and Ireland. BTO Books, Thetford.

Band, W. (2000). Wind farms and Birds: calculating a theoretical collision risk assuming no avoiding action. Scottish Natural Heritage Guidance Note.

Band, W., Madders, M., and Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. and Ferrer, M. (eds.) *Birds and Wind Farms: Risk Assessment and Mitigation*. Madrid, Quercus. p. 259-275.

Band, B. (2011). Using a collision risk model to assess bird collision risks for offshore wind farms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. BTO and The Crown Estate. British Trust for Ornithology, Norfolk. Originally published Sept 2011, extended to deal with flight height distribution data March 2012.

Band, B. (2012). Using a collision risk model to assess bird collision risks for offshore wind farms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. BTO and The Crown Estate. British Trust for Ornithology, Norfolk. Originally published Sept 2011, extended to deal with flight height distribution data March 2012.

Barrio Froján, C., Callaway, A., Whomersley, P., Stephens, D. and Vanstaen, K. (2013) Benthic Survey of Inner Dowsing, Race Bank and North Ridge cSAC, and of Haisborough, Hammond and Winterton cSAC. Cefas.

Barton C., Pollock C. and Harding N. (2009). *Arklow Bank seabird and marine mammal monitoring programme. Year 8.* A report to Airtricity.

BOWL (2016) UXO Clearance Marine Licence – Environmental Report. Beatrice Offshore Wind Farm. September 2016.

BERR (2007). Aerial surveys of waterbirds in Strategic Wind Farm Areas: 2005/2006 Final Report. Department of Business, Environment and Regulatory Reform, London.

BMT Cordah (2003) Ross-worm non-technical report. Report to Subsea 7 as part of contract for ConocoPhillips p. 8.

Bonner, W. N. (1982) Seals and man: a study of interactions. Washington Sea Grant Publication: 143–161

Brandt, M.J., Diederichs, A., Betke, K. and Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Marine Ecology Progress Series. 421, pp.205 – 216.

Brown, A. and Grice, P. (2005). Birds in England. London, Poyser.

Bussell J. and Saunders I. (2010) An appraisal and synthesis of data identifying areas of ross worm, Sabellaria spinulosa, reef in The Wash. NE commissioned report.

Camphuysen, C.J., Fox, T., Leopold, M.F. and Petersen, I.K. (2004). *Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK*. A report for COWRIE.

Centrica (2017) A-Fields Decommissioning Saturn (Annabel) and Audrey Fields Environmental Impact Assessment. Document ID: CEU-DCM-SNS0096-REP-0009. September 2017.

Chartered Institute of Ecology and Environmental Management (CIEEM) (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. Second Edition.

Collins, M.B., Shimwell, S.J., Gao, S., Powell, H., Hewitson, C. and Taylor, J.A. (1995). Water and sediment movement in the vicinity of linear sandbanks: the Norfolk Banks, southern North Sea. Marine Geology, 123, 125-142.

Collins, J. (ed.) (2016) Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd edn). The Bat Conservation Trust, London. ISBN-13 978-1-872745-96-1

Connor, D.C., Allen, J.H., Golding, N., Howell, K., Lie Berknecht, L.M., Northen, K.O. and Reker, J.B. (2004) The Marine Habitat Classification For Britain And Ireland Version 04.05. [Online] JNCC: Peterborough. Available from: www.jncc.gov.uk/marinehabitatclassification [Accessed 22 May 2017].

Cook, A.S.C.P., Humphreys, E.M., Masden, E.A. and Burton, N.H.K. (2014) The avoidance rates of collision between birds and offshore turbines. Thetford: British Trust for Ornithology.

Coulson, J.C., 2011. *The Kittiwake*. London: T. & A.D. Poyser.

Cramp, S. and Perrins, C.M. (1977 - 1994). H*andbook of the birds of Europe, the Middle East and Africa. The birds of the western Palearctic*. Oxford, Oxford University Press.

Dähne, M., Gilles, A., Lucke, K., Peschko, V., Adler, S., Krugel, K., Sundermeyer, J. and Siebert, U. (2013). Effects of pile-driving on harbour porpoises (Phocoena phocoena) at the first offshore wind farm in Germany. Environmental Research Letters 8.

Daunt, F., Benvenuti, S., Harris, M.P., Dall'Antonia, L., Elston, D.A. and Wanless, S., 2002. Foraging strategies of the black-legged kittiwake Rissa tridactyla at a North Sea colony: evidence for a maximum foraging range. *Marine Ecology Progress Series*, 245, pp. 239-247.

David (2006) Risks of collision for fin whales in the north-western Mediterranean Sea in summer. Fins: 16-18

De-Bastos, E.S.R. and Hill, J. (2016) *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand. In: Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. [Online] Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/habitat/detail/124 [Accessed 22 May 2017].

Department of Energy and Climate Change (DECC) (2011) Offshore Energy Strategic Environmental Assessment: OEnvironmental StatementEA2 Environmental Report - Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil and Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure. Department for Energy and Climate Change. URN 10D/1024.

DECC (2009). Aerial Surveys of Waterbirds in the UK: 2007/08, Final Report. Department of Energy and Climate Change, London.

Department for Business, Energy and Industrial Strategy (BEIS) (2017) Record of the Habitats Regulations Assessment for Viking and LOGGS Phase 1 Decommissioning and Strategic Review of proposed further decommissioning at Viking and LOGGS. September 2017.

Department for Environment, Food and Rural Affairs (Defra) (2016a) Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ) Fact Sheet. [Online] Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492323/mcz-cromer-shoal-chalk-beds-factsheet.pdf. [Accessed 22 May 2017].

Dierschke, V. and Garthe, S. (2006). Literature review of offshore wind farms with regards to seabirds. In: Zucco, C., Wende, W., Merck, T., Köchling, I. and Köppel, J. (eds.): *Ecological research on offshore wind farms: international exchange of experiences. Part B: literature review of ecological impacts.* BfN-Skripten 186: 131–198.

DONG Energy (2016a) Hornsea Project Three Offshore Wind Farm Environmental Impact Assessment: Scoping Report. [Online] Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-000065-Scoping%20Report.pdf. [Accessed 24 May 2017].

DONG Energy (2016b). Race Bank Offshore Wind Farm Method Statement for Local Levelling and Disposal of Drill Arisings. Submitted in support of an application to the Marine Management Organisation for a Marine Licence for the works.

DONG Energy (2017). Race Bank Offshore Wind Farm Export Cable Sandwave Levelling Monitoring Data (various). Available from https://marinelicensing.marinemanagement.org.uk (application reference: MLA/2015/00452/5) [Accessed on 29 March 2018].

DTI (2006). Aerial Surveys of Waterbirds in Strategic Windfarm Areas: 2004/05, Final Report. Department of Trade and Industry, London.

Dyer, K.R. and Huntley, D.A. (1999) The origin, classification and modelling of sand banks and ridges. Continental Shelf Research 19, 1285-1330.

Jessop, R.W., Akesson, O. and Smith, L.M. (2012) Eastern IFCA Research Report.

Eaton, M.A., Aebischer, N.J., Brown, A.F., Hearn, R., Lock, L., Musgrove, A.J., Noble, D., Stroud, D. and Gregory, R.D. (2015). Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man. *British Birds* 108, 708-746.

Elliott, M., Nedwell, S., Jones, N.V., Read, S.J., Cutts, N.D. and Hemmingway, K.L. (1998) Intertidal sand and mudflats & subtidal mobile sandbank (Volume II). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. Scottish Association of Marine Science (UK Marine SACs Project) p. 151.

EMODnet (2017) EUSeaMap. [Online] Available from: http://www.emodnet-seabedhabitats.eu/default.aspx?page=1974. [Accessed 22 May 2017].

EGS (2012) Lynn and Inner Dowsing Offshore Wind Farms. Survey of Benthic Communities within Jack-up Footprints. Report for Centrica Renewable Energy Ltd. February 2012.

Energy Act (2004) Chapter 3: Decommissioning of offshore installations. [Online] Available from: http://www.legislation.gov.uk/ukpga/2004/20/pdfs/ukpga_20040020_en.pdf. [Accessed 23 May 2017].

English Nature (1997) The Appropriate Assessment (Regulation 48) The Conservation (Natural Habitats &C) Regulations 1994. Habitats Regulations Guidance Note HRGN 1.

English Nature (2003) The Humber Estuary European Marine Site, English Nature's advice given under Regulation 33(2) of the Conservation (Natural Habitats & c.) Regulations 1994, Interim advice.

English Nature (1999) Habitats regulations guidance note: The Determination of Likely Significant Effect under The Conservation (Natural Habitats & c) Regulations 1994. HRGN 3.

Environment Agency, (2002) White-clawed crayfish (*Austropotamobius pallipes*) - Species Action Plan. [online]. Available from: <https://designatedsites.naturalengland.org.uk/UnitDetail.aspx?UnitId=1025558&SiteCode=S1006328&SiteName=river%20wensum&countyCode=&responsiblePerson=> [Accessed on 2 June 2017].

ERM Ltd (2012) Marine Aggregate Regional Environmental Assessment of the Humber and Outer Wash Region. Volumes 1 & 2. Report for the Humber Aggregate Dredging Association. Vol.1 p. 345 Vol.2 p. 231.

European Commission (2001) Assessment of plans and projects significantly affecting Natura 2000 sites – Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC. EC November 2001.

Evans, P.G.H., Anderwald, P., and Baines, M.E. (2003) UK cetacean status review. Report to English Nature and Countryside Council for Wales. Sea Watch Foundation, Oxford.

Everaert, J. (2006) Wind turbines and birds in Flanders: preliminary study results and recommendations. Natuur. Oriolus, 69(4), 145-155.

Everaert, J. (2008) Effecten van windturbines op de fauna in Vlaanderen : onderzoeksresultaten, discussie en aanbevelingen. Effects of wind turbines on fauna in Flanders - Study results, discussions and recommendations. Rapporten van het Instituut voor Natuur- en Bosonderzoek, 2008(44). Instituut voor Natuur- en Bosonderzoek: Brussel : Belgium.

Everaert, J. and Kuijken, E. (2007) Wind turbines and birds in Flanders (Belgium): Preliminary summary of the mortality research results. Belgian Research Institute for Nature and Forest.

Everaert, J., Devos, K. and Kuijken, E. (2002) Windturbines en vogels in Vlaanderen. Voorlopige onderzoeksresultaten en buitenlandse bevindingen. Report 2002.3, Instituut voor Natuurbehoud,Brussels. [Online] Available from http://publicaties.vlaanderen.be/docfolder/12563/Effecten_windturbines_op_de_fauna_Vlaanderen_2008.pdf. [Accessed 24 May 2017].

Everaert, J., Peymen, J. & van Straaten, D. (2011) Risico's voor vogels en vleermuizen bij geplande windturbines in Vlaanderen. Dynamisch beslissingsondersteunend instrument. Rapporten van het Instituut voor Natuur- en Bosonderzoek, INBO.R.2011.32. Instituut voor Natuur- en Bosonderzoek (INBO).

Finneran, J., Carder, J.D.A., Schlundt, C. and Dear, R.L. (2010). Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. Journal of the Acoustical Society of America 127:3267-3272.

Forrester, R.W., Andrews, I.J., McInerny, C.J., Murray, R.D., McGowan, R.Y., Zonfrillo, B., Betts, M.W., Jardine, D.C. and Grundy, D.S. (eds) (2007) The Birds of Scotland. The Scottish Ornithologists' Club, Aberlady.

Furness, R.W. (2015) Non-breeding season populations of seabirds in UK waters. Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Report NECR164.

Genesis (2011) Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Strategy Framework Directive. 2011. Genesis Oil and Gas Consultants report for the Department of Energy and Climate Change (DECC).

Geraci, J.R. and St. Aubin, D.J. (1980) Offshore petroleum resource development and marine mammals. A review and research recommendations. Marine fisheries review, 42:1-12.

Giroux, J-F. & Patterson, I.J. (1995) Daily movements and habitat use by radio-tagged Pinkfooted Geese *Anser brachyrhynchus* wintering in northeast Scotland.Wildfowl 46: 31-44.

Greenwood, P and Kuhn, N.J. (2014). Does the invasive plant, Impatiens glandulifera, promote soil erosion along the riparian zone? An investigation on a small watercourse in northwest Switzerland. Journal of Soils and Sediments, 14(3): 637–650.

Gubbay, S. (2007) Defining and managing *Sabellaria spinulosa* reefs: Report of an inter-agency workshop. Joint Nature Conservation Committee (JNCC), Peterborough. ISSN 0963-8091.

Götz, T., and Janik, V. (2016). The startle reflex in acoustic deterrence: an approach with universal applicability? Animal Conservation 19:225-226.

GWFL (2011) Galloper Wind Farm Project Environmental Statement - Chapter 11: Offshore Ornithology.

Hamer, K.C., Humphreys, E.M., Garthe, S., Hennicke, J., Peters, G., Grémillet, D., Phillips, R.A., Harris, M.P. and Wanless, S. (2007). Annual variation in diets, feeding locations and foraging behaviour of gannets in the North Sea: flexibility, consistency and constraint. *Marine Ecology Progress Series*, 338, 295-305.

Hamer, K.C., Monaghan, P., Uttley, J.D., Walton, P. and Burns, M.D. (1993). The influence of food supply on the breeding ecology of kittiwakes Rissa tridactyla in Shetland. *Ibis*, 135, 255-263.

Hammond P.S., Berggren P., Benke H., Borchers D.L., Collet A., Heide-Jørgensen M.P., Heimlich S., Hiby A.R. and Leopold M.F. (2002) Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology 39, 361–376.

Hammond, P.S. (2006) Small Cetaceans in the European Atlantic and North Sea (SCANS-II). Life project: LIFE04NAT/GB/000245.

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D., Burt, L., Cañadase, A., Desportes, G, Donovan, G.P., Gilles, A., Gillespie, D., Gordon, J., Hiby, L, Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C.G.M., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Seibert, U, Skovv, H., Swift, R., Tasker, M.L., Teilmann, J., Van Canneyt, O., Vázquezz, J.A. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation, Vol 164, pp107-122.

Hammond, P.S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., Macleod, K., Ridoux, V., Santos, M.B., Scheidat, M., Teilmann, J., Vingada, J. and Øien, N. (2017). Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. May 2017, 40 pp.

Harris, M.P. and Wanless, S., 2011. *The Puffin*. London: T. & A.D. Poyser.

Hastie, G.D., Barton, T.R., Grellier, K., Hammond, P.S., Swift, R.J., Thompson, P.M. and Wilson, B. (2003). Distribution of small cetaceans within a candidate Special Area of Conservation: implications for management. Journal of Cetacean Research and Management 5; 261-266.

Hatton-Ellis, T.W. & Grieve, N. (2003) Ecology of Watercourses Characterised by Ranunculion fluitantis and Callitricho-Batrachion Vegetation. Conserving Natura 2000 Rivers Ecology Series No. 11. English Nature, Peterborough.

Heinanen, S. and Skov, H (2015) The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area. JNCC Report No. 544.

Heinis, F., De Jong, C. and Rijkswaterstaat Underwater Sound Working Group (2015). Framework for assessing ecological and cumulative effects of offshore wind farms: Cumulative effects of impulsive underwater sound on marine mammals. Project number: 060.11480 & 060.14412. Report number: TNO 2015 R10335-A, TNO.

Heubeck, M., Harvey, P.V. and Okill, J.D. (1991) Changes in the Shetland guillemots *Uria aalge* population and the pattern of recoveries of ringed birds, 1959-1990. Seabird, 13, pp.3-21.

Hitchcock, D.R. and Bell, S. (2004) Physical impacts of marine aggregate dredging on seabed resources in coastal deposits. Journal of Coastal Research, p. 101-114.

Holdich, D. (2003) Ecology of the White-clawed Crayfish. Conserving Natura 2000 Rivers Ecology Series No. 1. English Nature, Peterborough.

Holt, T.J., Rees, E.I., Hawkins, S.J. and Seed. R. (1998) Biogenic Reefs (volume 9). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project).

Horswill, C. & Robinson R. A. 2015. Review of seabird demographic rates and density dependence. *JNCC Report No. 552.* Joint Nature Conservation Committee, Peterborough

IAMMWG (2013) Management Units for marine mammals in UK waters. JNCC, June 2013.

IAMMWG (2015) Management Units for cetaceans in UK waters (January 2015). JNCC Report No. 547, March 2015, 42 pp.

ICES (2001) North Sea Benthos Project 2000. [Online] Available from: http://www.vliz.be/vmdcdata/nsbp/index.php. [Accessed 22 May 2017].

Inger, R., Attril, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J., and Godley, B.J. (2009) Marine renewable energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology, 46. 1145-1153.

IPC (2010). Advice Note six: Preparation and submission of application documents. Bristol, IPC.

IWC (2006) 58th Annual Meeting of the International Whaling Commission. Ship strikes working group. First progress report to the conservation committee. Report No. IWC/58CC3

Jackson, A. and Hiscock, K. (2008) *Sabellaria spinulosa*. Ross worm. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme. [Online] Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/speciessensitivity.php. [Accessed 23 May 2017].

Jak, R.G., Bos, O.G., Witbaard, R. and Lindeboom, H.J. (2009) Conservation objectives for Natura 2000 sites (SACs and SPAs) in the Dutch sector of the North Sea. IMAREnvironmental Statement Rapp. C065/09.

Jenkins, C., Eggleton, J. Albrecht, J., Barry, J., Duncan, G., Golding, N. and O'Connor, J. (2015) North Norfolk Sandbanks and Saturn Reef cSAC/SCI management investigation report. JNCC/Cefas Partnership Report, No. 7. [Online] Available from: http://jncc.defra.gov.uk/pdf/Web_Cefas_JNCC_No.7_a.pdf. [Accessed 23 May 2017].

Jenssen, B.M. (1996) An overview of exposure to, and effects of, petroleum oil and organochlorine pollution in Grey seals (*Halichoerus grypus*).Science of the Total Environment 186 (1-2): 109-118.

Jessop, R.W., Hinni, S., Skinner,J. and Woo, J.R. (2010) Eastern Sea Fisheries District Research Report 2010. Eastern Sea Fisheries Joint Committee. King's Lynn.

Jessop, R.W. and Maxwell, E. (2011) Eastern IFCA Research report 2011.

Joint Nature Conservation Committee (JNCC) (2008) North Norfolk Sandbanks and Saturn Reef. [Online] Available from: http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0030358. [Accessed 23 May 2017].

JNCC (2010a) Offshore Special Areas of Conservation: North Norfolk Sandbanks and Saturn Reef, Special Area of Conservation (SAC) Selection Assessment, Version 5.0 (20 August 2010). [Online] Available from: http://jncc.defra.gov.uk/PDF/NNSandbanksAndSaturnReef_SACSAD_5.0.pdf. [Accessed 23 May 2017].

JNCC (2010b). The protection of marine European Protected Species from injury and disturbance – Draft guidance for the marine area in England and Wales and the UK offshore marine area. March 2010. JNCC, Natural England and Countryside Council for Wales (CCW).

JNCC (2012) Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef. Conservation Objectives and Advice on Operations. Version 6.0. September 2012

JNCC (2014a) Special Areas of Conservation (SAC) [Online]. Available at: http://jncc.defra.gov.uk/page-23. [Accessed 23 May 2017].

JNCC (2014b). Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review. Joint Nature Conservation Committee (JNCC), Natural England (NE), Natural Resource Wales (NRW), Northern Ireland Environment Agency (NIEA), Scottish Natural Heritage (SNH).

JNCC (2015a) Haisborough, Hammond and Winterton MPA. [Online] Available from:: http://jncc.defra.gov.uk/page-6534. [Accessed 23 May 2017].

JNCC (2015b) North Norfolk Sandbanks and Saturn Reef MPA. [Online] Available from:: http://jncc.defra.gov.uk/page-6537-theme=default. [Accessed 22 May 2017].

JNCC (2016) Marine Noise Registry: Information Document, Version 1. JNCC, Peterborough.

JNCC (2017a) Identifying the possible impacts of rock dump from oil and gas decommissioning on Annex I mobile sandbanks. JNCC Report 603.

JNCC (2017b). Identifying the possible impacts of rock dump from oil and gas decommissioning on Annex I mobile sandbanks. Contract reference C16-0287-1046.

JNCC (2017c). Seabird Monitoring Programme database. [Online]. Available at: http://jncc.defra.gov.uk/smp/ (Accessed January 2018).

JNCC (2017) Joint SNCB Interim Displacement Advice Note. Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments. [Online] Available from: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwj6lKvjwojUAhXrAcAKHZL4AaEQFggmMAA&url=http%3A%2F%2Fjncc.defra.gov.uk%2Fpdf%2FJoint_SNCB_Interim_Displacement_AdviceNote_2017.pdf&usg=AFQjCNGRaUvOothHlXPRcd3icFCrrpPsCQ. [Accessed 23 May 2017].

JNCC and Natural England (2013). JNCC and Natural England interim advice on Habitats Regulations Assessment (HRA) screening for seabirds in the non-breeding season. Peterborough: JNCC.

Joint Nature Conservation Committee, Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs / Northern Ireland Environment Agency, Natural England and Scottish Natural Heritage (2017) Joint SNCB Interim Displacement Advice Note. Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments. [Online] Available from: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwj6lKvjwojUAhXrAcAKHZL4AaEQFggmMAA&url=http%3A%2F%2Fjncc.defra.gov.uk%2Fpdf%2FJoint_SNCB_Interim_Displacement_AdviceNote_2017.pdf&usg=AFQjCNGRaUvOothHlXPRcd3icFCrrpPsCQ. [Accessed 23 May 2017].

Jones, E.L. and Russell, D.J. (2017) Updated grey seal (*Halichoerus grypus*) usage maps in the North Sea. vol. OEnvironmental StatementEA-15-65, Department of Energy and Climate Change.

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

Jones, D. (2017). North Norfolk sugar beet yields touches 100t/ha. [Online] Available from: http://www.fwi.co.uk/arable/north-norfolk-sugar-beet-yield-hitting-100tha.htm. [Accessed 14 March 2018].

Kastelein, R.A., Hoek, L., Gransier, R., Rambags, M. and Claeys, N. (2014). Effect of level, duration, and inter-pulse interval of 1-2 kHz sonar signal exposures on harbour porpoise hearing. Journal of the Acoustical Society of America, 136:412-422.

Kober. K., Webb. A., Win. I., Lewis. M., O'Brien. S., Wilson. L.J., Reid. J.B. (2010). An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs. JNCC Report, No. 431.

Krijgsveld, K.L., Fijn, R.C., Heunks, C.P., van Horssen, W., de Fouw, J., Collier, M.P., Poot, M.J.M., Beuker, D. and Dirksen, S. (2010) Effect Studies Offshore Wind Farm Egmond aan Zee. Progress report on fluxes and behaviour of flying birds covering 2007 and 2008. Bureau Waardenburg report 09-023. Bureau Waardenburg, Culemborg.

Krijgsveld, K.L., Fijn, R.C., Japink, M., van Horssen, P.W., Heunks, C., Collier, M.P., Poot, M.J.M., Beuker, D. and Dirksen, S. (2011) Effect studies Offshore Wind Farm Egmond aan Zee: Final report on fluxes, flight altitudes and behaviour of flying birds. NoordzeeWind report nr OWEZ_R_231_T1_20111114_fluxandflight, Bureau Waardenburg report nr 10-219.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. (2001) Collisions between ships and whales. Marine Mammal Science 17: 35-75.

Langhamer 2012 in Pidduck *et al.,* 2017Langston, R.H.W., Teuten, E. and Butler, A. (2013) Foraging ranges of northern gannets Morus bassanus in relation to proposed offshore wind farms in the North Sea: 2010-2012. Sandy: Royal Society for the Protection of Birds

Last, K., Hendrick, V. and Beveridge, C. (2011) Tolerance of *Sabellaria spinulosa* to aqueous chlorine. Final Report for the BEEMS programme, Work Package 6.

Lawson, J., Kober, K., Win, I., Allcock, Z., Black, J., Reid, J.B., Way, L. and O'Brien, S.H. (2015) An assessment of the numbers and distributions of wintering red-throated diver, little gull and common scoter in the Greater Wash. JNCC Report 574. Peterborough: JNCC.

Leopold, M.F., Dijkman, E.M., Teal, L. and the OWEZ-team (2010). *Local birds in and around the Offshore Wind Farm Egmond aan Zee (OWEZ). NoordzeeWind rapport OWEZ_R_221_T1_20100731_local_birds*. Imares / NoordzeeWind, Wageningen / IJmuiden.

Leopold, M.F., Dukman, E.M., and Teal, L. (2011). *Local Birds in and around the Offshore Wind Farm Egmond aan Zee (OWEZ) (T-0 and T-1, 2002-2010)*. Texel, The Netherlands, Wageningen IMARES.

Lewis, S., Grémillet, D., Daunt, F., Ryan, P.G., Crawford, R.J. and Wanless, S., 2006. Using behavioural and state variables to identify proximate causes of population change in a seabird. *Oecologia*, 147, pp. 606−614.

Linley E.A.S., Wilding T.A., Black K., Hawkins A.J.S. and Mangi S. (2007) Review of the reef effects of offshore wind farm structures and their potential for enhancement and mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform Contract No: RFCA/005/0029P (BERR).

Lucke K, Lepper P A, Blanchet M (2009) Temporary shift in masked hearing thresholds in a harbour porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. J. Acoust. Soc. Am. 125(6) 4060-4070.

Lusseau, D., New, L., Donovan, C., Cheney, B., Thompson, P. M., Hastie, G., & Harwood, J (2011) The development of a framework to understand and predict the population consequences of disturbances for the Moray Firth bottlenose dolphin population. Scottish Natural Heritage Commissioned Report No. 468.

Lusseau, D., Christiansen, F, Harwood, J., Mendes, S., Thompson, P.M., Smith, S., Hastie, G.D. (2012). Assessing the risks to marine mammals from renewable energy devices: an interim approach. CCW, JNCC, NERC Workshop 21st June 2012. Final report. Available at: https://ke.services.nerc.ac.uk/Marine/Members/Documents/Workshop%20outputs/CCW%20JNCC%20NERC%20workshop%20final%20report.pdf. [Accessed 7 November 2013]

MacArthur Green (2017). *Estimates of Ornithological Headroom in Offshore Wind Farm Collision Mortality*. The Crown Estate.

MacArthur Green, 2015. *MacArthur Green Seabird PBA Report.* [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed March 2018).

Maclean, I.M.D., Wright, L.J., Showler, D.A., and Rehfisch, M.M. (2009). A review of assessment methodologies for offshore wind farms. British Trust for Ornithology Report, commissioned by COWRIE Ltd.

Malme, C. I., Miles, P. R., Miller, G. W., Richardson, W. J., Reseneau, D. G., Thomson, D. H., Greene, C. R. (1989) Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska, BBN Report No. 6945 OCS Study MMS 89-0005. Reb. From BBN Labs Inc., Cambridge, MA, for U.S. Minerals Managements Service, Anchorage, AK. NTIS PB90-188673.

Marine Life (2017) Recent Sightings. [Online] Available from: http://www.marine-life.org.uk/sightings. [Accessed 24 May 2017].

Marine Scotland – Licensing Operations Team, 2017. *Scoping Opinion. Addendum: Ornithology.* [Online]. Available at: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ICOLRevised-2017/SO-Add-Ornith (Accessed January 2018).

MarLIN (2017) The Marine Life Information Network. [Online] Available from: http://www.marlin.ac.uk/. [Accessed 23 May 2017].

Marshall, C.E. (2008) *Mysella Bidentata* and *Thyasira* spp. in Circalittoral Muddy Mixed Sediment. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [Online] Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/habitatbenchmarks.php?habitatid=374&code. [Accessed 22 May 2017].

Masden, E.A. (2015) Developing an avian collision risk model to incorporate variability and uncertainty. Environmental Research Institute North Highland College – UHI University of the Highlands and Islands.

McLeod, C.R. (1996) Glossary of marine ecological terms, acronyms and abbreviations used in MNCR work. In: Marine Nature Conservation Review: rationale and methods, (Ed. K. Hiscock), Appendix 1, p. 93-110. Peterborough: Joint Nature Conservation Committee. [Coasts and seas of the United Kingdom, MNCR Series].

McIlwaine, P, Rance, J and Froján, C. B. (2014) Continuation of Baseline Monitoring of Reef Features in The Wash and North Norfolk Coast Special Area of Conservation (SAC). Cefas Report: C5814, July 2014, 56pp.

Mead, C. J. (1974) The results of ringing auks in Britain and Ireland. Bird Study 21: 45-86.

Meadows, B and Froján, C. B. (2012) Baseline Monitoring Survey of Large Shallow Inlet and Bay for The Wash and North Norfolk Coast SAC. Cefas Report: C5518, 22nd March 2012, 54pp.

Mendel, B., Kotzerka, J., Commerfield, J., Schwemmer, H., Sonntag, N. and Garthe, S. (2014). *Effects of the alpha ventus offshore test site on distribution patterns, behaviour and flight heights of seabirds*. Federal Maritime and Hydrographic Agency

Mitchell, C. & Hearn, R., (2004) Pink-footed Goose *Anser brachyrhynchus* (Greenland/Iceland population) in Britain 1960/61 – 1999/2000. Waterbird Review Series, The Wildfowl & Wetlands Trust/Joint Nature Conservation Committee, Slimbridge.

Mitchell, P.I., Newton, S.F., Ratcliffe, N. and Dunn, T.E. (2004). Seabird populations of Britain and Ireland. Poyser, London.

Mooney, T.A., Nachtigall, P.E. and Vlachos, S. (2009). Sonar-induced temporary hearing loss in dolphins. Biology Letters.

Moorkens, E.A. and Killeen, I.J., (2011) Monitoring and Condition Assessment of Populations of *Vertigo geyeri*, *Vertigo angustior* and *Vertigo moulinsiana* in Ireland. Irish Wildlife Manuals, No. 55. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

MS-LOT, 2017. Scoping opinion for the proposed section 36 consent and associated marine licence application for the revised inch cape offshore wind farm and revised inch cape offshore transmission works. [Online]. Available at: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ICOLRevised-2017 (Accessed October 2017).

Musgrove, A.J., Aebicher, N.J., Eaton, M.A., Hearn, R.D., Newson, S.E., Noble, D.G., Parsons, M., Risely, K. and Stroud, D.A., 2013. Population estimates of birds in Great Britain and the United Kingdom. British Birds, 106, pp. 64-100.

National Marine Fisheries Service (NMFS) (2016). Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

Natural England, (2010) River Wensum SSSI - LENWADE MILL - TAVERHAM MILL (053). [online]. Available from:<https://designatedsites.naturalengland.org.uk/UnitDetail.aspx?UnitId=1025558&SiteCode=S1006328&SiteName=river%20wensum&countyCode=&responsiblePerson=> [Accessed on 2 June 2017].

Natural England (2013) Planning Inspectorate Reference: EN010025. [Online] Available from:: https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwietLm6oljUAhWsJ8AKHTwJAskQFggiMAA&url=https%3A%2F%2Finfrastructure.planninginspectorate.gov.uk%2Fwp-content%2Fuploads%2F2013%2F03%2F10016987-Natural-England-and-JNCC1.pdf&usg=AFQjCNGC2pzGvsrbtD_Z45a1LGctQaWSkA. [Accessed 24 May 2017].

Natural England (2013b). Walney Extension Offshore Wind Farm Application. Written Representations of Natural England. Planning Inspectorate Reference: EN010027.

Natural England (2014a) *Conservation Objectives for European Sites in England: Strategic Standard*. 01/02/2014 V1.0

Natural England (2014b). *Departmental brief: Proposed extension to Flamborough Head and Bempton Cliffs Special Protection Area and renaming as flamborough and filey coast potential Special Protection Area (pSPA).* Natural England.

Natural England, (2014c) Site Improvement Plan Norfolk Valley Fens. [pdf]. Avaialble from: <http://publications.naturalengland.org.uk/file/4592297601662976> [Accessed on 2 June 2017].

Natural England, (2014d) Site Improvement Plan River Wensum. [pdf]. Avaialble from: <http://publications.naturalengland.org.uk/file/5795274547003392> [Accessed on 2 June 2017].

Natural England (2014e) European Site Conservation Objectives for The Wash & North Norfolk Coast SAC (UK0017075). [Online] Available from: http://publications.naturalengland.org.uk/publication/5950176598425600. [Accessed 23 May 2017].

Natural England (2015a). Hornsea Offshore Wind Farm Project Two. Written Submission for Deadline 3: Appendix 4. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed October 2017).

Natural England (2015b). Hornsea Offshore Wind Farm Project Two. Written Submission for Deadline 3: Appendix 5. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed October 2017).

Natural England (2015c). Hornsea Offshore Wind Farm Project Two. Written Submission for Deadline 3: Appendix 6. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed October 2017).

Natural England (2015d). Hornsea Offshore Wind Farm Project Two. Relevant Representations of Natural England. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

Natural England (2015e) Departmental Brief: Coquet Island Special Protection Area (SPA) – site amendment. [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492866/coquet-island-departmental-brief.pdf (Accessed March 2018).

Natural England (2015f) Departmental Brief: Farne Islands Special Protection Area (SPA) – site amendment. [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492878/farne-islands-departmental-brief.pdf (Accessed March 2018).

Natural England, (2015g) Priority Habitats' Inventory version 2.1. [online]. Avaialble from: <http://www.gis.naturalengland.org.uk/pubs/gis/GIS_register.asp> [Accessed on 2 June 2017].

Natural England (2017a) The Wash and North Norfolk Coast SAC Supplementary Advice. 15th September 2017.

Natural England (2017c) Annex 1 - Alkaline Fens, Transition Mire, Quaking Bog Polygons. [online]. Avaialble from: <http://naturalengland-defra.opendata.arcgis.com/datasets/25b917e001604570b37a9b1800a4e886_2> [Accessed on 7 February 2018].

Natural England (2017d) North Norfolk Coast SPA. Supplementary advice. [online]. Avaialble from: <https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK9009031&SiteName=was&SiteNameDisplay=North+Norfolk+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=> [Accessed on 6 April 2018].

Natural England and JNCC (2016) Departmental Brief: Greater Wash potential Special Protection Area. [Online] Available from: https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjw8Mu1yojUAhVJAsAKHf8uC3UQFggmMAA&url=https%3A%2F%2Fconsult.defra.gov.uk%2Fnatural-england-marine%2Fgreater-wash-potential-special-protection-area-com%2Fsupporting_documents%2FV9%2520FINAL%2520Greater%2520Wash%2520Departmental%2520Brief%252017%2520October%25202016%2520ready%2520for%2520consultation.pdf&usg=AFQjCNGY6lziuiPze4KTTbsKo-dYNb8SGg. [Accessed 24 May 2017].

Nelson, B., 2002. *The Atlantic Gannet*. 2nd Edn. Great Yarmouth: Fenix Books Limited.

Nelson, E., Vallejo, G., Canning, S., Kerr, D., Caryl, F., McGregor, R., Rutherford, V. and Lancaster, J. (2015) *Analysis of Marine Ecology Monitoring Plan Data – Robin Rigg Offshore Wind Farm*. [Online]. Available at: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Robin-Rigg (Accessed March 2018).

Net Gain (2011) Final Recommendations Submission to Natural England & JNCC. [Online] Available from: http://webarchive.nationalarchives.gov.uk/20120502152708/http:/www.netgainmcz.org/docs/Net_Gain_Final_Rec_v1_1.pdf. [Accessed 23 May 2017].

Newell, R.C., Seiderer, L. J., Simpson, N. M. and Robinson, J.E. (2002) Impact of Marine Aggregate Dredging and Overboard Screening on Benthic Biological Resources in the Central North Sea: Production Licence Area 408, Coal Pit. British Marine Aggregate Producers Association, Technical Report No. ER1/4/02, 72pp.

Niel, C. and Lebreton, J-D. (2005). Using Demographic Invariants to Detect Overharvested Bird Populations from Incomplete Data. *Conservation Biology*. 19 (3), pp. 826-835.

nPower Renewables (2008). *North Hoyle Offshore Wind Farm FEPA Monitoring Final Report*.

O'Brien, S.H., Wilkson, L.J., Webb, A. and Cranswick, P.A. (2008) Revised estimate of numbers of wintering Red-throated Divers *Gavia stellata* in Great Britain. Bird Study 55, 152–160.

ODPM Circular (06/2005) *Government Circular: Biodiversity and Geological conservation – Statutory obligations and their impact within the planning system*. ISBN 0 11 753951 1

Oil and Gas UK (2015) UKbenthos Database. [Online] Available from: http://oilandgasuk.co.uk/product/ukbenthos/. [Accessed 22 May 2017].

OSPAR Commission (2010) Quality Status Report 2010: Case Reports for the OSPAR List of threatened and/or declining species and habitats – Update. Sabellaria spinulosa reefs.

Pace, D. S., A. Miragliuolo, and B. Mussi (2006) Vessels and dolphins; scars that tell stories. Fins: 19-20

Palka and Hammond (2001) Accounting for responsive movement in line transect estimates of abundance. Canadian Journal of Fisheris and Aquatic Science 58: 777-787

Parsons, M., Lawson, J., Lewis, M., Lawrence, R. & Kuepfer, A. (2015) Quantifying foraging areas of little tern around its breeding colony SPA during chick-rearing. JNCC Report No. 548.

Parvin, S.J., Nedwell, J.R., Harland, E. (2007). Lethal and physical injury of marine mammals, and requirements for Passive Acoustic Monitoring. Subacoustech Report No. 565R0212; 2nd February 2007. 41 pp.

Paxton, C.G.M., Scott-Hayward, L., Mackenzie, E., Rexstad, E., and Thomas, L. (2016) Revised Phase III Data Analysis of Joint Cetacean Protocol Data Resources. JNCC Report and Advisory Note No. 517, 208 pp.

Pearce, B., Taylor, J. and Seiderer, L.J. (2007) Recoverability of *Sabellaria spinulosa* following aggregate extraction. Marine Ecological Surveys Limited.

Pearson, T.H., 1968. The feeding biology of seabird species breeding on the Fame Islands, Northumberland. *Journal of Animal Ecology*, 37, pp. 521-552.

Pennington, M., Osborn, K., Harvey, P., Riddington, R., Okill, D., Ellis, P. & Heubeck, M. 2004. The Birds of Shetland. Helm, A & C Black, London.

Perrow, M.R., Gilroy, J.J., Skeate, E.R. and Mackenzie, A. (2010). *Quantifying the relative use of coastal waters by breeding terns: towards effective tools for planning & assessing the ornithological impact of offshore wind farms*. [Online]. Available at: https://www.thecrownestate.co.uk/media/450936/ei-km-ex-pc-birds-062010-planning-and-assessing-the-ornithological-impact-of-offshore-wind-farms-breeding-terns.pdf (Accessed January 2018).

Petersen, I.K., Christensen, T.K., Kahlert, J., Desholm, M. and Fox, A.D. (2006). *Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. NERI Report Commissioned by Ørsted and Vattenfall A/S 2006.* National Environmental Research Institute Ministry of the Environment-Denmark, Denemarken.

PINS (2015) Cumulative Effects Assessment. [Online] Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf. [Accessed 23 May 2017].

PINS (2017) Habitats Regulations Assessment. [Online] Available from: http://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/06/Advice-note-10v4.pdf [Accessed 20 March 2018].

Pirotta, E., Merchant, N.D., Thompson, P.M., Barton, T.R., & Lusseau, D. (2015). Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. Biological Conservation 181: 82-89.

Plunkett, R. (2017) Seal telemetry data in relation to the Hornsea 3 project, report number SMRUC-RPS-2017-008, Submitted to RPS, March 2017 (Unpublished).

Precision marine Survey Ltd (PMSL) (2016) Humber Gateway Offshore Wind Farm: Annex I Post Construction Survey. Report to E.ON Climate and Renewables UK Limited.

Reed, T.E., Harris, M.P. and Wanless, S. (2015) Skipped breeding in common guillemots in a changing climate: restraint or constraint?. *Frontiers in Ecology and Evolution.* 3, pp. 1-13.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (2003) Atlas of Cetacean distribution in northwest European waters, Joint Nature Conservation Committee (JNCC), Peterborough.

Richardson, W.J., Greene, C.R. Jr., Malme, C.I., and Thomson, D.H. (1995) Marine Mammals and Noise. Academic Press, San Diego, CA, USA. 576p.

Riou, S., Gray, C.M., Brooke, M.D., Quillfeldt, P., Masello, J.F., Perrins, C. and Hamer, K.C., 2011. Recent impacts of anthropogenic climate change on a higher marine predator in western Britain. *Marine Ecology Progress Series*, 422, pp. 105-112.

Robinson, R.A., 2017. BirdFacts: profiles of birds occurring in Britain and Ireland. [Online]. Available at: http://www.bto.org/birdfacts (Accessed May 2017)

Royal Haskoning (2009) Dudgeon Offshore Wind Farm. Environmental Statement, Section 10: Marine Ecology. Prepared on behalf of Dudgeon Offshore Wind Limited p. 53.

RPS (2012). Lincs / LID6 Offshore Wind Farm – Boat-based Ornithological Monitoring: Construction Phase. Report for CREL.

RSPB (2008) Advise to farmers. Pink-footed Goose. [Online]. Available from: https://www.rspb.org.uk/our-work/conservation/conservation-and-sustainability/farming/advice/details.aspx?id=203990 [Accessed 29 June 2017].

Ruddock, M. and Whitfield, D.P. (2007) A Review of Disturbance Distances in Selected Bird Species. [Online]. Available from: http://www.snh.org.uk/pdfs/strategy/renewables/birdsd.pdf [Accessed 24 May 2017].

Russell, D.J., Hastie, G.D., Thompson, D., Janik, V.M., Hammond, P.S., Scott-Hayward, L.A., Matthiopoulos, J., Jones, E.L., and McConnell, B.J. (2016). Avoidance of wind farms by harbour seals is limited to pile driving activities. Journal of Applied Ecology.

Russell, D., Jones, E. & Morris, C. (2017) Updated Seal Usage Maps: The Estimated at-sea Distribution of Grey and Harbour Seals. *Scottish Marine and Freshwater Science,* Vol 8, No 25.

Scira Offshore Energy (2006) Sheringham Shoal offshore wind farm. Environmental Statement.

Scottish Natural Heritage (2009). *Citation for Special Protection Area (SPA). Forth Islands.* [Online]. Available at: https://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8500 (Accessed March 2018).

Sea Mammal Research Unit (SMRU) (2004). SMRU Scientific Report 1999 – 2004. September 2004. Available from [http://www.smru.st-and.ac.uk/documents/SMRU_Scientific_Report.pdf] Downloaded 31 July 2012.

Sea Mammal Research Unit (SMRU) (2011) Summary of seal count and telemetry data from the Humber area. Report to SMart Wind.

Sea Mammal Research Unit (SMRU) (2017) Grey and Harbour Seal Telemetry Report: Seal telemetry data in relation to Hornsea 3 Project. SMRUC-RPS-2017-008. May 2017.

Šefferová, S.V., Šeffer, J. & Janák, M. (2008) Management of Natura 2000 habitats. 7230 Alkaline fens. 24, European Commission, Brussels.

Senior, B., Bailey, H., Lusseau, D., Foote A., & Thompson, P.M. (2008) Anthropogenic noise in the Moray Firth SAC; potential sources and impacts on bottlenose dolphins. Scottish Natural Heritage Commissioned Report No.265 (ROAME No.F05LE02).

Sini, M. I., Canning, S. J., Stockin, K. A., & Pierce, G. J. (2005) Bottlenose dolphins around Aberdeen harbour, north-east Scotland: a short study of habitat utilization and the potential effects of boat traffic. Journal of the Marine Biological Association of the UK 85: 1547-1554.

SMart Wind (2013). Hornsea Offshore Wind Farm Project One. Environmental Statement Volume 5 – Offshore Annexes Chapter 5.5.1 Ornithology Technical Report. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-one/?ipcsection=docs (Accessed March 2018).

SMart Wind (2015a) Hornsea Offshore Wind Farm Project Two Environmental Statement Volume 5 – Offshore Annexes; Annex 5.5.1 Ornithology Technical Report. PINS Document Reference 7.5.5.1.. Smart Wind Limited.

SMart Wind (2015b). Hornsea Offshore Wind Farm Project Two. Memorandum of Understanding between the Applicant and Natural England. Appendix Q to the Response submitted for Deadline VII. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

SMartWind (2015c). Clarification Note – Apportioning of predicted guillemot mortality to the Flamborough and Filey Coast pSPA population Appendix O to the Response submitted for Deadline IIA. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

Southall B L, Bowles A E, Ellison W T, Finneran J J, Gentry R L, Green Jr. C R, Kastak D, Ketten D R, Miller J H, Nachtigall P E, Richardson W J, Thomas J A, Tyack P L (2007) Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, 33 (4), pp. 411-509.

Special Committee on Seals (SCOS) (2011) Scientific Advice on Matters Related to the Management of Seal Populations: 2011. Sea Mammal Research Unit. Available from: http://www.smru.st-andrews.ac.uk/documents/678.pdf. [Accessed 24 May 2017].

Special Committee on Seals (SCOS) (2012) Scientific Advice on Matters Related to the Management of Seal Populations: 2012. Sea Mammal Research Unit. Available from: http://www.smru.st-andrews.ac.uk/documents/1199.pdf. [Accessed 24 May 2017].

Special Committee on Seals (SCOS) (2013) Scientific Advice on Matters Related to the Management of Seal Populations: 2013. Sea Mammal Research Unit. Available from: http://www.smru.st-andrews.ac.uk/documents/1803.pdf. [Accessed 24 May 2017].

Special Committee on Seals (SCOS) (2014) Scientific Advice on Matters Related to the Management of Seal Populations: 2014. Sea Mammal Research Unit. Available from: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0ahUKEwj63bCSoojUAhVMKMAKHUU_CYMQFgg4MAM&url=http%3A%2F%2Fwww.smru.st-andrews.ac.uk%2Ffiles%2F2016%2F08%2FSCOS-2014.pdf&usg=AFQjCNEQYxFKwld8UYxpo5uD7ZRPcGoTcQ. [Accessed 24 May 2017].

Special Committee on Seals (SCOS) (2015) Scientific Advice on Matters Related to the Management of Seal Populations: 2015. Sea Mammal Research Unit. Available from: http://www.smru.st-andrews.ac.uk/files/2016/08/SCOS-2015.pdf. [Accessed 24 May 2017].

Special Committee on Seals (SCOS) (2016) Scientific Advice on Matters Related to the Management of Seal Populations: 2015. Sea Mammal Research Unit. Available from: http://www.smru.st-andrews.ac.uk/files/2017/04/SCOS-2016.pdf. [Accessed 24 May 2017].

Stienen, E.W.M., van Waeyenberge, J., Kuijken, E. and Seys, J. (2007). Trapped within the corridor of the Southern North Sea: the potential impact of offshore wind farms on seabirds. In: Birds and Wind Farms - Risk assessment and Mitigation (eds. de Lucas M., Janss G.F.E. and Ferrer M.), p. 71-80. Quercus, Madrid, Spain.

Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Redd, T.C., Tasker, M.L., Camphuysen, C.J. and Pienkowski, M.W. (1995) An atlas of seabird distribution in north-west European waters. Joint Nature Conservation Committee and Nederlands Institute voor Onderzoek der Zee, Peterborough.

Tappin, D.R., Pearce, B., Fitch, S., Dove, D., Gearey, B., Hill, J.M., Chambers, C., Bates, R., Pinnion, J., Diaz Doce, D. and Green, M (2011) The Humber regional environmental characterisation. Marine Aggregate Levy Sustainability Fund.

Teilmann, J., Larsen, F. and Desportes, G. (2007) Time allocation and diving behaviour of harbour porpoise (Phocoena phocoena)in Danish and adjacent waters. Journal of Cetacean Management, 2007, vol 9.

Teilmann, J., Christiansen, C. T., Kjellerup, S., Dietz, R., and Nachman, G. (2013) Geographic, seasonal, and diurnal surface behavior of harbor porpoises. Marine mammal science, 29(2), E60-E76.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S., Roos, S., Bolton, M., Langston, R.H. and Burton, N.H. (2012) Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. Biological Conservation, 156, p. 53-61.

The Planning Inspectorate (2012). Scoping Opinion Proposed Hornsea Project Two. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed March 2018).

Thomson, P.M., Brookes, K.L., Graham, I.M., Barton, T.R., Needham, K., Bradbury, G., Merchant, N.D. (2013a). Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. Proceedings of the Royal Society B, 280: 20132001.

Thompson, P.M., Hastie, G., Nedwell, J., Barham, R., Brooker, A., Brookes, K., Cordes, L., Bailey, H.,and McLean, N. (2013b). Framework for assessing the impacts of pile driving noise from offshore wind farm construction on Moray Firth harbour seal populations. Environmental Impact Assessment Review 43: 73–85.

Tillin, H.M. (2016a) Nephtys cirrosa and Bathyporeia spp. in infralittoral sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/154 [Accessed on 4 January 2018].

Tillin, H.M. (2016b) Moerella spp. with venerid bivalves in infralittoral gravelly sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1111 [Accessed on 4 January 2018].

Tillin, H.M. (2016c) Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1131 [Accessed on 4 January 2018].

Tillin, H.M. (2016d) Abra prismatica, Bathyporeia elegans and polychaetes in circalittoral fine sand. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/habitat/detail/1133 [Accessed on 4 January 2018].

Tillin, H.M. and Marshall, C.M. (2015) *Sabellaria spinulosa* on stable circalittoral mixed sediment. In: Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [Online] Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/habitats/detail/377/sabellaria_spinulosa_on_stable_circalittoral_mixed_sediment. [Accessed 24 May 2017].

Tillin, H.M. and Rayment, W. (2016) *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand. In: Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [Online] Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/habitats/detail/142. [Accessed 24 May 2017].

Vanermen N., Stienen E.W.M., Courtens W., Onkelinx T., Van de walle M. and Verstraete H. (2013). Bird monitoring at offshore wind farms in the Belgian part of the North Sea - Assessing seabird displacement effects. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (INBO.R.2013.755887). Instituut voor Natuur- en Bosonderzoek, Brussels.

Vanerman, N., Courtens, W., Van de walle, M., Verstraete, H. and Stienen, E.W.M. (2017). *Seabird monitoring at the Thorntonbank offshore wind farm. Updated seabird displacement results & an explorative assessment of large gull behavior inside the wind farm area*. Brussels: Instituut voor Natuur- en Bosonderzoek.

Van Waerebeek, K., Baker, A.N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G.P., Secchi, E., Sutaria, D., van Helden, A. and Wang, Y. (2007) Vessel collisions with small cetaceans worldwide and with large whales in the southern hemisphere, and initial assessment. LAJAM 6: 43-69.

Wade H.M., Masden. E.A., Jackson, A.C. and Furness, R.W. (2016) Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy, 70, 108–113.

Wakefield, E.D., Bodey, T.W., Bearhop, S., Blackburn, J., Colhoun, K., Davies, R., Dwyer, R.G., Green, J.A., Grémillet, D., Jackson, A.L., Jessopp, M.J., Kane, A., Langston, R.H.W., Lescroël, A., Murray, S., Le Nuz, M., Patrick, S.C., Péron, C., Soanes, L.M., Wanless, S., Votier, S.C. and Hamer, K.C. (2013). Space Partitioning Without Territoriality in Gannets. Science, 341 (6141), 68-70.

Walls, R. Canning, S., Lye, G., Givens, L., Garrett, C. and Lancaster, J. (2013). Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1). Natural Power report for E.ON Climate and Renewables.

Wanless, S., Murray, S. and Harris, M.P., 2005. The status of Northern Gannet in Britain & Ireland in 2003/04. Birtish Birds, 98, 280-294.

Watkins, W.A. (1986). Whale reactions to human activities in Cape Cod waters. Marine Mammals Science 2: 251-262.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Sirwardena, G.M. and Baillie, S.R. (Eds). (2002) The Migration Atlas: movement of the birds of Britain and Ireland. Poyser.

Wildfowl and Wetlands Trust (WWT) Wetlands Advisory Service (2006) Aerial surveys of waterbirds in strategic wind farm areas: winter 2004/05 – interim report. WWT report to Department of Trade and Industry. May 2006. 44pp.

Wilson, (1970). The larvae of Sabellaria spinulosaand their settlement behaviour. Journal of the Marine Biological Association of the United Kingdom, 50, 33-52.

Wilson L. J., Black J., Brewer, M. J., Potts, J. M., Kuepfer, A., Win I., Kober K., Bingham C., Mavor R. & Webb A. (2014) Quantifying usage of the marine environment by terns *Sterna* sp. around their breeding colony SPAs. JNCC Report No. 500.

WWT Consulting and MacArthur Green (2013). *Seabird sensitivity mapping in English territorial waters*. Natural England.

Appendix A Effects on benthic ecology in relation to the specific attributes of the Conservation Objectives

Table 9.1: The Wash and North Norfolk Coast SAC Assessment Matrix – Construction/Decommissioning

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning **Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning** **Potential Impact: Accidental pollution during construction/decommissioning**								
					Alternative route		Original route	
European Site	Qualifying Feature	Conservation Objective	Attributes	Conservation Objective target	Assessment overview/justification	Conclusion of effect on site integrity	Assessment overview/justification	Conclusion of effect on site integrity
The Wash and North Norfolk Coast SAC	Sandbanks which are slightly covered by sea water all the time	To ensure that, subject to natural change, the extent and distribution of qualifying natural habitats are maintained or restored	Presence and spatial distribution of biological communities	Maintain the presence and spatial distribution of subtidal sandbank communities	The proposed cable route is located near the eastern edge of the site. Sediment transport in the region is in an easterly direction. Analysis of historic and site specific data does not indicate the presense of Annex I Sandbanks which are slightly covered by sea water all the time coinciding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occuring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurance of this biotope in this location is not indicitive of this feature in this instance.	No effect on site integrity anticipated	The proposed cable route is located near the eastern edge of the site. Sediment transport in the region is in an easterly direction. Analysis of historic and site specific data does not indicate the presense of Annex I Sandbanks which are slightly covered by sea water all the time coinciding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occuring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurance of this biotope in this location is not indicitive of this feature in this instance.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
			Extent and distribution	Maintain the total extent and spatial distribution of subtidal sandbanks to ensure no loss of integrity, while allowing for natural change and succession.	A maximum area of 2,356,714 m^2 of the subtidal habitats within The Wash and North Norfolk Coast SAC is predicted to be impacted by temporary habitat loss/disturbance (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements), which represents 0.22% of the total area of The Wash and North Norfolk Coast SAC. The temporary loss/disturbance will be highly localised to the vicinity of the construction activity (i.e. limited to the immediate footprints) and will occur over the maximum construction phase of up to eight years. Individual activities resulting in temporary habitat loss/disturbance will occur intermittently throughout this time with only a small proportion of the total area of habitat to be affected being impacted at any one time. The maximum design scenario for temporary habitat loss/disturbance assumes that pre-construction sandwave clearance would occur along the entire extent of export cables within The Wash and North Norfolk Coast SAC. This is, however, a precautionary assumption and there may be discrete areas in which sandwave clearance will not be required but boulder clearance may be required and although this will not contribute to any additional habitat loss, the process will effectively redistribute boulders and cobbles within discrete areas and potentially concentrate these in the areas either side of the 25 m boulder clearance corridor.	No effect on site integrity anticipated	A maximum area of 1,488,339km^2 of the subtidal habitats within The Wash and North Norfolk Coast SAC is predicted to be impacted by temporary habitat loss/disturbance (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements), which represents 0.14% of the total area of The Wash and North Norfolk Coast SAC. The temporary loss/disturbance will be highly localised to the vicinity of the construction activity (i.e. limited to the immediate footprints) and will occur over the maximum construction phase of up to eight years. Individual activities resulting in temporary habitat loss/disturbance will occur intermittently throughout this time with only a small proportion of the total area of habitat to be affected being impacted at any one time. The maximum design scenario for temporary habitat loss/disturbance assumes that pre-construction sandwave clearance would occur along the entire extent of export cables within The Wash and North Norfolk Coast SAC. This is, however, a precautionary assumption and there may be discrete areas in which sandwave clearance will not be required but boulder clearance may be required and although this will not contribute to any additional habitat loss, the process will effectively redistribute boulders and cobbles within discrete areas and potentially concentrate these in the areas either side of the 25 m boulder clearance corridor.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning **Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning** **Potential Impact: Accidental pollution during construction/decommissioning**								
		To ensure that, subject to natural change, the structure and function (including typical species) of qualifying natural habitats are maintained or restored	Presence and abundance of key structural and influential species	[Maintain OR Recover OR Restore] the abundance of listed species, to enable each of them to be a viable component of the habitat.	See above - due to the absence of characterisitc Annex I sandbank communities in the proposed working cable corridor there exists no risk to the ability of key structural and influential species being viable componants of Annex I Sandbanks which are slightly covered by sea water all the time where they occur within the site.	No effect on site integrity anticipated	See above - due to the absence of characterisitc Annex I sandbank communities in the proposed working cable corridor there exists no risk to the ability of key structural and influential species being viable componants of Annex I Sandbanks which are slightly covered by sea water all the time where they occur within the site.	No effect on site integrity anticipated
			Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.	The proposed activities during construction/decommissioning do not represent a risk for the introduction or spread of non-native species and pathogens	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk for the introduction or spread of non-native species and pathogens	No effect on site integrity anticipated
			Sediment composition and distribution	Maintain the distribution of sediment composition across the feature (and each of its subfeatures).	Sandwave clearance material from sandwaves cleared within The Wash and North Norfolk Coast SAC will be deposited within the boundary of The Wash and North Norfolk Coast SAC at a location that considers the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see section 1.11.5 in ES volume 1, chapter 1: Marine Processes).	No effect on site integrity anticipated	Sandwave clearance material from sandwaves cleared within The Wash and North Norfolk Coast SAC will be deposited within the boundary of The Wash and North Norfolk Coast SAC at a location that considers the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see section 1.11.5 in ES volume 1, chapter 1: Marine Processes).	No effect on site integrity anticipated
			Species composition of component communitie s	Maintain the species composition of component communities.	The proposed activities during construction/decommissioning are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of Annex I Sandbanks which are slightly covered by sea water all the time within this site	No effect on site integrity anticipated	The proposed activities during construction/decommissioning are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of Annex I Sandbanks which are slightly covered by sea water all the time within this site	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
			Topography	Maintain the presence of topographic characteristics of the feature, while allowing for natural responses to hydrodynamic regime, by preventing erosion or deposition through human induced activity.	The mobility of material in the nearshore area is such that under storm conditions, the combined action of currents and waves is expected to remobilise sediments with grain size of up to 100 mm (cobbles) in the shallowest water depths of up to 8 m and up to 15 mm (pebble gravel) in deeper nearshore areas (up to 14 m). This demonstrates that, over time, there will be a redistribution of the material displaced during boulder clearance and, whilst it is not possible to determine where the sediment will be redistributed to, it is reasonable to assume that some of the material will be moved back in to the areas which were cleared, thus partially restoring the topography of the area. Jack up operations, cable trenching also has the potential to leave scars on the seabed, the persistence of which will depend on the local seabed characteristics and ambient hydrodynamic conditions (see section 1.11.2 in ES volume 2, chapter 1: Marine Processes). In areas where mobile sands and gravels are present, such as are present across the majority of the Hornsea Three study area coinciding with The Wash and North Norfolk SAC, these scars are likely to be temporary features which may only persist for a period of weeks to months. However, even if scars persist for longer they are not expected to have implications for sediment transport; they are simply local depressions that will infill over time.	No effect on site integrity anticipated	The mobility of material in the nearshore area is such that under storm conditions, the combined action of currents and waves is expected to remobilise sediments with grain size of up to 100 mm (cobbles) in the shallowest water depths of up to 8 m and up to 15 mm (pebble gravel) in deeper nearshore areas (up to 14 m). This demonstrates that, over time, there will be a redistribution of the material displaced during boulder clearance and, whilst it is not possible to determine where the sediment will be redistributed to, it is reasonable to assume that some of the material will be moved back in to the areas which were cleared, thus partially restoring the topography of the area. Jack up operations, cable trenching also has the potential to leave scars on the seabed, the persistence of which will depend on the local seabed characteristics and ambient hydrodynamic conditions (see section 1.11.2 in ES volume 2, chapter 1: Marine Processes). In areas where mobile sands and gravels are present, such as are present across the majority of the Hornsea Three study area coinciding with The Wash and North Norfolk SAC, these scars are likely to be temporary features which may only persist for a period of weeks to months. However, even if scars persist for longer they are not expected to have implications for sediment transport; they are simply local depressions that will infill over time.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
			Volume	Maintain the existing volume of sediment in the sandbank, allowing for natural change.	The proposed sandwave clearance activities will result in local displacement of the disturbed sediment volume, which will remain the same sediment type as the surrounding seabed (i.e. it is reasonable to assume similarity of sediment particle size with depth based on sediment transport processes) and with no loss of seabed sediments from the local area. In the case of dredging, assuming that any material excavated is disposed of in close proximity to the dredge location, no sediment volume will be removed from the sandbank systems overall. The displaced material will be of the same or similar sediment type (mineralogy and grain size distribution) as the surrounding seabed and, following re-settlement, will be immediately available again for transport at the naturally occurring rate and direction, controlled entirely by natural processes. As such, the sediment will have immediately re-joined the natural sedimentary environment within the local area and so by definition is not 'lost from the system' due to the dredging/spoil disposal process.	No effect on site integrity anticipated	The proposed sandwave clearance activities will result in local displacement of the disturbed sediment volume, which will remain the same sediment type as the surrounding seabed (i.e. it is reasonable to assume similarity of sediment particle size with depth based on sediment transport processes) and with no loss of seabed sediments from the local area. In the case of dredging, assuming that any material excavated is disposed of in close proximity to the dredge location, no sediment volume will be removed from the sandbank systems overall. The displaced material will be of the same or similar sediment type (mineralogy and grain size distribution) as the surrounding seabed and, following re-settlement, will be immediately available again for transport at the naturally occurring rate and direction, controlled entirely by natural processes. As such, the sediment will have immediately re-joined the natural sedimentary environment within the local area and so by definition is not 'lost from the system' due to the dredging/spoil disposal process.	No effect on site integrity anticipated
		To ensure that, subject to natural change, the supporting processes on which qualifying natural habitats are maintained or restored	Energy / exposure	Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes, and stability, across the habitat.	The proposed activities during construction/decommissioning do not represent a risk to natural physical energy resulting from waves, tides and other water flows - see sediment movement and hydrodynamic regime attribute below.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to natural physical energy resulting from waves, tides and other water flows - see sediment movement and hydrodynamic regime attribute below.	No effect on site integrity anticipated
			Physico-chemical properties	Maintain the natural physico-chemical properties of the water.	The proposed activities during construction/decommissioning do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
			Sediment contaminants	Restrict surface sediment contaminants (<1cm from the surface) to below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold. For example, mean cadmium levels should be maintained below the ERL of 1.2 mg per kg.	The proposed activities during construction/decommissioning do not represent a risk to altering surface sediment contaminants - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to altering surface sediment contaminants - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated
			Sediment movement and hydrodynamic regime	Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement are not significantly altered or prevented from responding to changes in environmental conditions	The patterns of processes governing the overall evolution of the systems (the flow regime, water depths and sediment availability) are at a much larger scale and so would not be affected by, the proposed local works. As a result, the proposed clearance is not likely to influence the overall form and function of the system and eventual recovery via natural processes is therefore expected. The rate of recovery would vary in relation to the rate of sediment transport processes, faster infill and recovery rates will be associated with higher local flow speeds and more frequent wave influence (see volume 1, chapter 1: Marine Processes). Where the sands are deposited into areas of different seabed type (e.g. areas of slightly coarser seabed in some sandwave troughs), the seabed may become locally relatively finer in texture until the body of sand has been winnowed away or reincorporated into a bedform migrating over that location. In all cases, the deposited sediments would be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions.	No effect on site integrity anticipated	The patterns of processes governing the overall evolution of the systems (the flow regime, water depths and sediment availability) are at a much larger scale and so would not be affected by, the proposed local works. As a result, the proposed clearance is not likely to influence the overall form and function of the system and eventual recovery via natural processes is therefore expected. The rate of recovery would vary in relation to the rate of sediment transport processes, faster infill and recovery rates will be associated with higher local flow speeds and more frequent wave influence (see volume 1, chapter 1: Marine Processes). Where the sands are deposited into areas of different seabed type (e.g. areas of slightly coarser seabed in some sandwave troughs), the seabed may become locally relatively finer in texture until the body of sand has been winnowed away or reincorporated into a bedform migrating over that location. In all cases, the deposited sediments would be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
			Water quality - contaminants	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 level	The proposed activities during construction/decommissioning do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated
			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.	The proposed activities during construction/decommissioning do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated
			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.	The proposed activities during construction/decommissioning do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated
			Water quality - turbidity	Maintain natural levels of turbidity (eg suspended concentrations of sediment, plankton and other material) across the habitat.	Although tempory increases in localised suspended sediments will occur due to activites occurring during construction/decommissioning these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated	Although tempory increases in localised suspended sediments will occur due to activites occurring during construction/decommissioning these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning

Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning

Potential Impact: Accidental pollution during construction/decommissioning

	Reefs	To ensure that, subject to natural change, the extent and distribution of qualifying natural habitats are maintained or restored	Presence and spatial distribution of biological communitie s	Maintain the presence and spatial distribution of reef communities.	A maximum area of 2,356,714 m^2 of the subtidal habitats within The Wash and North Norfolk Coast SAC is predicted to be impacted by temporary habitat loss/disturbance (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements), which represents 0.22% of the total area of The Wash and North Norfolk Coast SAC. The temporary loss/disturbance will be highly localised to the vicinity of the construction activity (i.e. limited to the immediate footprints) and will occur over the maximum construction phase of up to eight years. Individual activities resulting in temporary habitat loss/disturbance will occur intermittently throughout this time with only a small proportion of the total area of habitat to be affected being impacted at any one time. The occurrence of *Sabellaria* biotopes throughout the Hornsea Three offshore cable corridor, together with other data such as the Humber REC dataset and the HADA MAREA dataset, indicates a wide distribution throughout this part of the southern North Sea, which suggests that *S. spinulosa* reefs in this area are likely to be ephemeral and, although the specific locations may change, the propensity for the presence of reef in The Wash and North Norfolk Coast SAC coincidental with the Hornsea Three offshore cable corridor is evident, however, no Annex I reef habitat was recorded along the Hornsea Three offshore cable corridor coinciding with The Wash and North Norfolk Coast SAC and therefore no direct impact to this habitat is predicted, however given the evidence for the propensity for reef to develop in this area, pre-construction surveys will be used to identify the presence of such reefs and ensure that measures can be designed, if necessary, to avoid direct impacts.	No effect on site integrity anticipated	A maximum area of 1,488,339km^2 of the subtidal habitats within The Wash and North Norfolk Coast SAC is predicted to be impacted by temporary habitat loss/disturbance (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance and cable installation including anchor placements), which represents 0.14% of the total area of The Wash and North Norfolk Coast SAC. The temporary loss/disturbance will be highly localised to the vicinity of the construction activity (i.e. limited to the immediate footprints) and will occur over the maximum construction phase of up to eight years. Individual activities resulting in temporary habitat loss/disturbance will occur intermittently throughout this time with only a small proportion of the total area of habitat to be affected being impacted at any one time. The occurrence of Sabellaria biotopes throughout the Hornsea Three offshore cable corridor, together with other data such as the Humber REC dataset and the HADA MAREA dataset, indicates a wide distribution throughout this part of the southern North Sea, which suggests that S. spinulosa reefs in this area are likely to be ephemeral and, although the specific locations may change, the propensity for the presence of reef in The Wash and North Norfolk Coast SAC coincidental with the Hornsea Three offshore cable corridor is evident, however, no Annex I reef habitat was recorded along the Hornsea Three offshore cable corridor coinciding with The Wash and North Norfolk Coast SAC and therefore no direct impact to this habitat is predicted, however given the evidence for the propensity for reef to develop in this area, pre-construction surveys will be used to identify the presence of such reefs and ensure that measures can be designed, if necessary, to avoid direct impacts.	No effect on site integrity anticipated
			Extent and distribution	Maintain the total extent, spatial distribution and types of reef (and each of its subfeatures), subject to natural variation in sediment veneer				

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
		To ensure that, subject to natural change, the structure and function (including typical species) of qualifying natural habitats are maintained or restored	Presence and abundance of key structural and influential species	[Maintain OR Recover OR Restore] the abundance of listed species, to enable each of them to be a viable component of the habitat.	See above	No effect on site integrity anticipated	See above	No effect on site integrity anticipated
			Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.	The proposed activities during construction/decommissioning do not represent a risk to the introduction or spread of non-native species and pathogens.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to the introduction or spread of non-native species and pathogens.	No effect on site integrity anticipated
			Physical structure of rocky substrate	Maintain the surface and structural complexity, and the stability of the reef structure.	See above	No effect on site integrity anticipated	See above	No effect on site integrity anticipated
			Species composition of component communitie s	Maintain the species composition of component communities.	The proposed activities during construction/decommissioning are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of this Annex I habitat within this site.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of this Annex I habitat within this site.	No effect on site integrity anticipated
		To ensure that, subject to natural change, the supporting processes on which qualifying natural habitats are maintained or restored	Energy / exposure	Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes, and stability, across the habitat.	The proposed activities during construction/decommissioning do not represent a risk to natural physical energy resulting from waves, tides and other water flows.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to natural physical energy resulting from waves, tides and other water flows.	No effect on site integrity anticipated
			Physico-chemical properties	Maintain the natural physico-chemical properties of the water.	The proposed activities during construction/decommissioning do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning

Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning

Potential Impact: Accidental pollution during construction/decommissioning

			Sedimentation rate	Maintain the natural rate of sediment deposition to avoid smothering of the feature.	The maximum design scenario for increases in SSC associated with export cable installation are predicted to occur because of installation by mass flow excavator (see ES volume 2, chapter 1: Marine Processes for full details). Disturbance of medium to coarse sand and gravels during cable installation is likely to result in a temporally and spatially limited plume affecting SSC levels (and settling out of suspension) near the point of release. SSC will be locally elevated within the plume close to active cable burial up to tens or hundreds of thousands of mg/l, although the change will only be present for a very short time locally (i.e. seconds to tens of seconds) before the material resettles to the seabed. Depending on the height to which the material is ejected and the current speed at the time of release, changes in SSC and deposition will be spatially limited to within metres downstream of the cable for gravels and within tens of metres for sands. Finer material will be advected away from the release location by the prevailing tidal current. High initial concentrations are to be expected but will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. Only a small proportion of the material disturbed is expected to be fines, with a corresponding reduction in the expected levels of SSC. Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited (up to 6 m^3 per metre of cable burial) which also limits the combinations of sediment deposition thickness and extent that might realistically occur. The assessment presented in ES volume 2, chapter 1: Marine Processes suggests that the extent and so the area of deposition will normally be much smaller for sands and gravels, leading to a greater average thickness of deposition in the order of tens of centimetres to a few metres in the immediate vicinity of the cable trench. Fine material, by contrast, will be distributed much more widely, becoming so dispersed that it is unlikely to settle in measurable thickness locally. The installation of cables in nearshore areas of the Hornsea Three offshore cable corridor may occur in areas of seabed where chalk is present at or very close to the	No effect on site integrity anticipated	The maximum design scenario for increases in SSC associated with export cable installation are predicted to occur because of installation by mass flow excavator (see ES volume 2, chapter 1: Marine Processes for full details). Disturbance of medium to coarse sand and gravels during cable installation is likely to result in a temporally and spatially limited plume affecting SSC levels (and settling out of suspension) near the point of release. SSC will be locally elevated within the plume close to active cable burial up to tens or hundreds of thousands of mg/l, although the change will only be present for a very short time locally (i.e. seconds to tens of seconds) before the material resettles to the seabed. Depending on the height to which the material is ejected and the current speed at the time of release, changes in SSC and deposition will be spatially limited to within metres downstream of the cable for gravels and within tens of metres for sands. Finer material will be advected away from the release location by the prevailing tidal current. High initial concentrations are to be expected but will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres of the point of release. Only a small proportion of the material disturbed is expected to be fines, with a corresponding reduction in the expected levels of SSC. Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited (up to 6 m^3 per metre of cable burial) which also limits the combinations of sediment deposition thickness and extent that might realistically occur. The assessment presented in ES volume 2, chapter 1: Marine Processes suggests that the extent and so the area of deposition will normally be much smaller for sands and gravels, leading to a greater average thickness of deposition in the order of tens of centimetres to a few metres in the immediate vicinity of the cable trench. Fine material, by contrast, will be distributed much more widely, becoming so dispersed that it is unlikely to settle in measurable thickness locally. The installation of cables in nearshore areas of the	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning								
			Water quality - contaminants	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 level	The proposed activities during construction/decommissioning do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated
			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.	The proposed activities during construction/decommissioning do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated
			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.	The proposed activities during construction/decommissioning do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated
			Water quality - turbidity	Maintain natural levels of turbidity (eg suspended concentrations of sediment, plankton and other material) across the habitat.	Although tempory increases in localised suspended sediments will occur due to activites occurring during construction/decommissioning these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated	Although tempory increases in localised suspended sediments will occur due to activites occurring during construction/decommissioning these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated

Table 9.2 The Wash and North Norfolk Coast SAC Assessment Matrix – Operation and Maintenance

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**								
					Alternative route		Original route	
European Site	Qualifying Feature	Conservation Objective	Attributes	Conservation Objective target	Assessment overview/justification	Conclusion of effect on site integrity	Assessment overview/justification	Conclusion of effect on site integrity
The Wash and North Norfolk Coast SAC	Sandbanks which are slightly covered by sea water all the time	To ensure that, subject to natural change, the extent and distribution of qualifying natural habitats are maintained or restored	Presence and spatial distribution of biological communities	Maintain the presence and spatial distribution of subtidal sandbank communities.	The permanent habitat loss predicted to occur within The Wash and North Norfolk Coast SAC due to ativities associated with Hornsea Three is up to 46,200 m^2 (i.e. from cable protection where burial is not possible). This represents 0.0043% of the total area of The Wash and North Norfolk Coast SAC. Analysis of historic and site specific data does not indicate the presense of Annex I Sandbanks which are slightly covered by sea water all the time coinsiding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occuring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurance of this biotope in this location is not indicitive of this feature in this instance. As the overall proportion of The Wash and North Norfolk	No effect on site integrity anticipated	The permanent habitat loss predicted to occur within The Wash and North Norfolk Coast SAC due to ativities associated with Hornsea Three is up to 29,442 m^2 (i.e. from cable protection where burial is not possible) This represents 0.0027% of the total area of The Wash and North Norfolk Coast SAC. Analysis of historic and site specific data does not indicate the presense of Annex I Sandbanks which are slightly covered by sea water all the time coinsiding with the cable corridor within the boundary of the site. The biotopes identified within the section of the cable corridor occuring within The Wash and North Norfolk Coast SAC are not characteristic of sandbank communities with the exception of the NcirBat biotope, however; the occurance of this biotope in this location is not indicitive of this feature in this instance.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**								
			Extent and distribution	Maintain the total extent and spatial distribution of subtidal sandbanks to ensure no loss of integrity, while allowing for natural change and succession.	Coast SAC predicted to be affected is very small, 0.0043% of the total area of the site, there will remain sufficient similar available habitat for the creation of Annex I ‘Sandbanks which are slightly covered by seawater all the time’. Therefore, it is not considered that the presence of cable protection will preclude the establishment of Annex I Sandbanks which are slightly covered by seawater all the time in these areas in the future. Additionally it is likely that a degree of, if not all, the cable protection will become covered in sediment by natural processes potentially providing a suitable habitat for settlement and establishment of sabellaria reef. The total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance predicted to affect Annex I ‘Sandbanks which are slightly covered by seawater all the time’ habitat, within The Wash and North Norfolk Coast SAC over the 25 year design life of Hornsea Three as a result of export cable remedial burial and repair activities is is up to 188,302 m^2. This equates to approximately 0.02% of the total habitat within The Wash and North Norfolk Coast SAC. It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 7% of the total export cable length coincides with The Wash and North Norfolk Coast SAC, 7% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. The associated communities are predicted to recover rapidly from disturbance of this nature.		As the overall proportion of The Wash and North Norfolk Coast SAC predicted to be affected is very small, 0.0027% of the total area of the site, there will remain sufficient similar available habitat for the creation of Annex I ‘Sandbanks which are slightly covered by seawater all the time’. Therefore, it is not considered that the presence of cable protection will preclude the establishment of Annex I Sandbanks which are slightly covered by seawater all the time in these areas in the future. Additionally it is likely that a degree of, if not all, the cable protection will become covered in sediment by natural processes potentially providing a suitable habitat for settlement and establishment of sabellaria reef. The total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance predicted to affect Annex I ‘Sandbanks which are slightly covered by seawater all the time’ habitat, within The Wash and North Norfolk Coast SAC over the 25 year design life of Hornsea Three as a result of export cable remedial burial and repair activities is within is up to 126,500 m^2. This equates to approximately 0.012% of the total habitat within The Wash and North Norfolk Coast SAC. It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 4.3% of the total export cable length coincides with The Wash and North Norfolk Coast SAC, 4.3% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site. The associated communities are predicted to recover rapidly from disturbance of this nature.	

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance								
		To ensure that, subject to natural change, the structure and function (including typical species) of qualifying natural habitats are maintained or restored	Presence and abundance of key structural and influential species	[Maintain OR Recover OR Restore] the abundance of listed species, to enable each of them to be a viable component of the habitat.	See above	No effect on site integrity anticipated	see above	No effect on site integrity anticipated
			Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.	The introduction of up to 57,135 m^2 of surface area of new hard substrate is predicted to occur within The Wash and North Norfolk Coast SAC. This is predicted to affect up to 0.005% of the potential Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC and as such represents a very small area for potential INNS colonisation. Furthermore, designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will ensure that the risk of potential introduction and spread of INNS will be minimised.	No effect on site integrity anticipated	The introduction of up to 36,359 m^2 of surface area of new hard substrate is predicted to occur within The Wash and North Norfolk Coast SAC. This is predicted to affect up to 0.0034% of the potential Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within The Wash and North Norfolk Coast SAC and as such represents a very small area for potential INNS colonisation. Furthermore, designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will ensure that the risk of potential introduction and spread of INNS will be minimised.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance

Potential Impact: Colonisation of hard structures during operation/maintenance

Potential Impact: Changes in physical processes during operation/maintenance

Potential Impact: Temporary seabed disturbance during operation/maintenance

Potential Impact: Accidental pollution during operation/maintenance

			Sediment composition and distribution	Maintain the distribution of sediment composition across the feature (and each of its subfeatures).	Installation of cable protection could result in a local elevation of the seabed profile by up to 2 m. Cable protection would be placed onto the seabed surface above the cable and therefore could present an obstacle to sediment transport, trapping sediment locally and thereby impacting down-drift locations through a reduction in sediment supply. Potential effects on sediment transport can only occur following installation of the cable protection and under conditions where sediment is being actively transported in a manner that is both susceptible to such blockage and in a direction that intersects the cable protection. The potential magnitude of any effect is correspondingly reduced if and when the rate of transport is naturally low, if the mode of sediment transport includes a larger proportion of material in high saltation or suspension, and/or where the axis of the cable protection and the local direction of sediment transport are relatively more aligned. At worst, the obstacle presented by the cable protection will locally prevent the onward passage of all sediment in transport, causing that sediment to accumulate locally. As the accumulated sediment volume increases, any open voids in the protection would become infilled and a sediment slope would develop on the updrift side (with a maximum slope angle equal to the angle of repose for sand ~30 degrees). As the stable slope approaches the top of the protection (up to 2 m above the seabed), the blockage effect of the cable protection will be progressively reduced to near zero and sediment will subsequently be transported directly over the obstacle (via the sediment slope and/or in saltation or suspension) unimpeded, at the naturally occurring ambient rate and direction. The maximum volume of sediment that could potentially accumulate in this way is limited by the dimensions of the protection to approximately 3.46 m^3 of sediment per metre of cable protection, which is small in both absolute and relative terms. The maximum dimensions of morphological change (seabed lowering) that might result from the	No effect on site integrity anticipated	Installation of cable protection could result in a local elevation of the seabed profile by up to 2 m. Cable protection would be placed onto the seabed surface above the cable and therefore could present an obstacle to sediment transport, trapping sediment locally and thereby impacting down-drift locations through a reduction in sediment supply. Potential effects on sediment transport can only occur following installation of the cable protection and under conditions where sediment is being actively transported in a manner that is both susceptible to such blockage and in a direction that intersects the cable protection. The potential magnitude of any effect is correspondingly reduced if and when the rate of transport is naturally low, if the mode of sediment transport includes a larger proportion of material in high saltation or suspension, and/or where the axis of the cable protection and the local direction of sediment transport are relatively more aligned. At worst, the obstacle presented by the cable protection will locally prevent the onward passage of all sediment in transport, causing that sediment to accumulate locally. As the accumulated sediment volume increases, any open voids in the protection would become infilled and a sediment slope would develop on the updrift side (with a maximum slope angle equal to the angle of repose for sand ~30 degrees). As the stable slope approaches the top of the protection (up to 2 m above the seabed), the blockage effect of the cable protection will be progressively reduced to near zero and sediment will subsequently be transported directly over the obstacle (via the sediment slope and/or in saltation or suspension) unimpeded, at the naturally occurring ambient rate and direction. The maximum volume of sediment that could potentially accumulate in this way is limited by the dimensions of the protection to approximately 3.46 m^3 of sediment per metre of cable protection, which is small in both absolute and relative terms. The	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance
Potential Impact: Colonisation of hard structures during operation/maintenance
Potential Impact: Changes in physical processes during operation/maintenance
Potential Impact: Temporary seabed disturbance during operation/maintenance
Potential Impact: Accidental pollution during operation/maintenance

			Species composition of component communities	Maintain the species composition of component communities.	The proposed activities during operation & maintenance are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of this Annex I habitat within this site.	No effect on site integrity anticipated	The proposed activities during operation & maintenance are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of this Annex I habitat within this site.	No effect on site integrity anticipated
			Topography	Maintain the presence of topographic characteristics of the feature, while allowing for natural responses to hydrodynamic regime, by preventing erosion or deposition through human induced activity.	The cable corridor is located at the far east of the site in a less dynamic and more homogenous area in comparison to other parts of the site e.g The Wash. The presense of cable protection is not anticipated to alter the topographic charateristics of the feature in the future and should sandbanks characteristic with the Annex I habitat "Sandbanks which are slightly covered by sea water all the time" form in this region in the future the presence of cable protection would not hinder the physical formation of this feature	No effect on site integrity anticipated	The cable corridor is located at the far east of the site in a less dynamic and more homogenous area in comparison to other parts of the site e.g The Wash. The presense of cable protection is not anticipated to alter the topographic charateristics of the feature in the future and should sandbanks characteristic with the Annex I habitat "Sandbanks which are slightly covered by sea water all the time" form in this region in the future the presence of cable protection would not hinder the physical formation of this feature	No effect on site integrity anticipated
			Volume	Maintain the existing volume of sediment in the sandbank, allowing for natural change.	The proposed activities during operation & maintenance are not anticipated to impact the volume of sediment available for the formation of this feature in this location in the future.	No effect on site integrity anticipated	The proposed activities during operation & maintenance are not anticipated to impact the volume of sediment available for the formation of this feature in this location in the future.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**								
		To ensure that, subject to natural change, the supporting processes on which qualifying natural habitats are maintained or restored	Energy / exposure	Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes, and stability, across the habitat.	The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on coastal habitats including Annex I habitats within The Wash and North Norfolk Coast SAC. However, the results of the wave assessment presented in ES volume 5, annex 1.1: Marine Processes Technical Report, indicates that although the presence of Hornsea Three will cause a localised reduction in wave heights, under all the wave conditions tested (magnitudes and directions), predicted measurable changes to wave heights due to the operational presence of Hornsea Three do not extend to the adjacent coastlines. Therefore, no effects are predicted on habitats within The Wash and North Norfolk Coast SAC as a result of changes to the wave regime. Impacts associated with cable protection will only exert a highly localised influence on the tidal regime such that the magnitude is considered to be negligible.	No effect on site integrity anticipated	The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on coastal habitats including Annex I habitats within The Wash and North Norfolk Coast SAC. However, the results of the wave assessment presented in ES volume 5, annex 1.1: Marine Processes Technical Report, indicates that although the presence of Hornsea Three will cause a localised reduction in wave heights, under all the wave conditions tested (magnitudes and directions), predicted measurable changes to wave heights due to the operational presence of Hornsea Three do not extend to the adjacent coastlines. Therefore, no effects are predicted on habitats within The Wash and North Norfolk Coast SAC as a result of changes to the wave regime. Impacts associated with cable protection will only exert a highly localised influence on the tidal regime such that the magnitude is considered to be negligible.	No effect on site integrity anticipated
			Physico-chemical properties	Maintain the natural physico-chemical properties of the water.	The proposed activities during operation & maintenance do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance								
			Sediment contaminants	Restrict surface sediment contaminants (<1cm from the surface) to below the OSPAR Environment Assessment Criteria (EAC) or Effects Range Low (ERL) threshold. For example, mean cadmium levels should be maintained below the ERL of 1.2 mg per kg.	The proposed activities during operation & maintenance do not represent a risk to altering surface sediment contaminants - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to altering surface sediment contaminants - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated
			Sediment movement and hydrodynamic regime	Maintain all hydrodynamic and physical conditions such that natural water flow and sediment movement are not significantly altered or prevented from responding to changes in environmental conditions	Sediment transport is in a predominantly easterly direction and considering the location of the proposed cable route at the easterly edge of the site the presense of any potential cable protection would not present a barrier to the formation of this feature within the site. Any localised "barrier effect" to the movement of sediment would be temporary (whilst sediments collect on the stoss side) and highly unlikely especially when considering the low elevation and variable orientation of any potential cable protection.	No effect on site integrity anticipated	Sediment transport is in a predominantly easterly direction and considering the location of the proposed cable route at the easterly edge of the site the presense of any potential cable protection would not present a barrier to the formation of this feature within the site. Any localised "barrier effect" to the movement of sediment would be temporary (whilst sediments collect on the stoss side) and highly unlikely especially when considering the low elevation and variable orientation of any potential cable protection.	No effect on site integrity anticipated
			Water quality - contaminants	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 level	The proposed activities during operation & maintenance do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance								
			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.	The proposed activities during operation & maintenance do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated
			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.	The proposed activities during operation & maintenance do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated
			Water quality - turbidity	Maintain natural levels of turbidity (eg suspended concentrations of sediment, plankton and other material) across the habitat.	Although tempory increases in localised suspended sediments may occur due to maintenance activites these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated	Although tempory increases in localised suspended sediments may occur due to maintenance activites these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance								
	Reefs	To ensure that, subject to natural change, the extent and distribution of qualifying natural habitats are maintained or restored	Presence and spatial distribution of biological communities	Maintain the presence and spatial distribution of reef communities.	The impact of long term habitat loss within The Wash and North Norfolk Coast SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the eastern periphery of The Wash and North Norfolk Coast SAC. Hornsea Three will discuss and agree the most appropriate cable protection measures for the Wash and North Norfolk Coast SAC, taking into account the local baseline environment. This may include the use of rock protection which takes into account the typical grain sizes (e.g. coarse gravel and cobbles) known to occur naturally within the SAC. Where appropriately sized rock protection can be used, such measures may allow some recovery of communities in areas where cable protection is placed and	No effect on site integrity anticipated	The impact of long term habitat loss within The Wash and North Norfolk Coast SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the eastern periphery of The Wash and North Norfolk Coast SAC. Hornsea Three will discuss and agree the most appropriate cable protection measures for the Wash and North Norfolk Coast SAC, taking into account the local baseline environment. This may include the use of rock protection which takes into account the typical grain sizes (e.g. coarse gravel and cobbles) known to occur naturally within the SAC. Where appropriately sized rock protection can	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance								
			Extent and distribution	Maintain the total extent, spatial distribution and types of reef (and each of its subfeatures), subject to natural variation in sediment veneer	reducing the extent of long term habitat loss in The Wash and North Norfolk Coast SAC. Historically, no reefs have been recorded in the area of the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC and neither were they recorded during the site specific surveys in this area. Therefore, no direct effects from long term habitat loss are predicted. It is acknowledged however, that the presence of the cable protection material on the seabed has the potential to act as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. The MarESA for the SspiMx biotope does note, however, that S. spinulosa has been recorded colonising bedrock and artificial structures and an increase in the availability of hard substratum may, therefore, be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different. Furthermore, as the overall proportion of The Wash and North Norfolk Coast SAC predicted to be affected is very small, 0.0043% of the total area of the site, there will remain sufficient similar habitat available for the potential colonisation by *S. spinulosa* and establishment of reefs in the future. Therefore, it is not considered that the presence of cable protection will preclude the establishment of Annex I reefs in these areas in the future. However, should Annex I *S. spinulosa* reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place to avoid direct impacts to these reefs from cable protection this will also apply to any maintenance operations occring across the lifetime of the development.		be used, such measures may allow some recovery of communities in areas where cable protection is placed and reducing the extent of long term habitat loss in The Wash and North Norfolk Coast SAC. Historically, no reefs have been recorded in the area of the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC and neither were they recorded during the site specific surveys in this area. Therefore, no direct effects from long term habitat loss are predicted. It is acknowledged however, that the presence of the cable protection material on the seabed has the potential to act as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. The MarESA for the SspiMx biotope does note, however, that S. spinulosa has been recorded colonising bedrock and artificial structures and an increase in the availability of hard substratum may, therefore, be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different. Furthermore, as the overall proportion of The Wash and North Norfolk Coast SAC predicted to be affected is very small, 0.0027% of the total area of the site, there will remain sufficient similar habitat available for the potential colonisation by *S. spinulosa* and establishment of reefs in the future. Therefore, it is not considered that the presence of cable protection will preclude the establishment of Annex I reefs in these areas in the future. However, should Annex I *S. spinulosa* reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place to avoid direct impacts to these reefs from cable protection this will also apply to any maintenance operations occring across the lifetime of the development.	

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**								
		To ensure that, subject to natural change, the structure and function (including typical species) of qualifying natural habitats are maintained or restored	Presence and abundance of key structural and influential species	[Maintain OR Recover OR Restore] the abundance of listed species, to enable each of them to be a viable component of the habitat.	See above	No effect on site integrity anticipated	see above	No effect on site integrity anticipated
			Non-native species and pathogens	Restrict the introduction and spread of non-native species and pathogens, and their impacts.	No reefs were identified within the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC during the site specific surveys and should Annex I reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place to avoid direct impacts to these reefs from cable protection. Furthermore, designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will ensure that the risk of potential introduction and spread of INNS will be minimised.	No effect on site integrity anticipated	No reefs were identified within the Hornsea Three benthic ecology study area coinciding with The Wash and North Norfolk Coast SAC during the site specific surveys and should Annex I reef be present in the pre-construction survey within The Wash and North Norfolk Coast SAC, appropriate measures will be put in place to avoid direct impacts to these reefs from cable protection. Furthermore, designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will ensure that the risk of potential introduction and spread of INNS will be minimised.	No effect on site integrity anticipated
			Physical structure of rocky substrate	Maintain the surface and structural complexity, and the stability of the reef structure.	See above	No effect on site integrity anticipated	see above	No effect on site integrity anticipated
			Species composition of component communities	Maintain the species composition of component communities.	The proposed activities during construction/decommissioning are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of this Annex I habitat within this site.	No effect on site integrity anticipated	The proposed activities during construction/decommissioning are not anticipated to impact the range, relative abundance or overall biodiversity of the species composition of componant communities of this Annex I habitat within this site.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance
Potential Impact: Colonisation of hard structures during operation/maintenance
Potential Impact: Changes in physical processes during operation/maintenance
Potential Impact: Temporary seabed disturbance during operation/maintenance
Potential Impact: Accidental pollution during operation/maintenance

		To ensure that, subject to natural change, the supporting processes on which qualifying natural habitats are maintained or restored	Energy / exposure	Maintain the natural physical energy resulting from waves, tides and other water flows, so that the exposure does not cause alteration to the biotopes, and stability, across the habitat.	The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on coastal habitats including Annex I habitats within The Wash and North Norfolk Coast SAC. However, the results of the wave assessment presented in ES volume 5, annex 1.1: Marine Processes Technical Report, indicates that although the presence of Hornsea Three will cause a localised reduction in wave heights, under all the wave conditions tested (magnitudes and directions), predicted measurable changes to wave heights due to the operational presence of Hornsea Three do not extend to the adjacent coastlines. Therefore, no effects are predicted on habitats within The Wash and North Norfolk Coast SAC as a result of changes to the wave regime. Impacts associated with cable protection will only exert a highly localised influence on the tidal regime such that the magnitude is considered to be negligible.	No effect on site integrity anticipated	The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on coastal habitats including Annex I habitats within The Wash and North Norfolk Coast SAC. However, the results of the wave assessment presented in ES volume 5, annex 1.1: Marine Processes Technical Report, indicates that although the presence of Hornsea Three will cause a localised reduction in wave heights, under all the wave conditions tested (magnitudes and directions), predicted measurable changes to wave heights due to the operational presence of Hornsea Three do not extend to the adjacent coastlines. Therefore, no effects are predicted on habitats within The Wash and North Norfolk Coast SAC as a result of changes to the wave regime. Impacts associated with cable protection will only exert a highly localised influence on the tidal regime such that the magnitude is considered to be negligible.	No effect on site integrity anticipated
			Physico-chemical properties	Maintain the natural physico-chemical properties of the water.	The proposed activities during operation & maintenance do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to the natural physico-chemical properties of the water - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated
			Sedimentation rate	Maintain the natural rate of sediment deposition to avoid smothering of the feature.	Any suspendend sediments arising from future maintenance activities would be of levels far reduced than those already assessed during construction.	No effect on site integrity anticipated	Any suspendend sediments arising from future maintenance activities would be of levels far reduced than those already assessed during construction.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance								
			Water quality - contaminants	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 level	The proposed activities during operation & maintenance do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of indusrty standard practices.	No effect on site integrity anticipated
			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.	The proposed activities during operation & maintenance do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk to maintaining dissolved oxygen levels at levels equating to High Ecological Status.	No effect on site integrity anticipated
			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.	The proposed activities during operation & maintenance do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated	The proposed activities during operation & maintenance do not represent a risk with regards to the alteration of existing nutrient levels.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**								
			Water quality - turbidity	Maintain natural levels of turbidity (eg suspended concentrations of sediment, plankton and other material) across the habitat.	Although tempory increases in localised suspended sediments will occur due to activites occurring during operation & maintenance these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated	Although tempory increases in localised suspended sediments will occur due to activites occurring during operation & maintenance these will radidly disperse and do not represent a risk at an ecosystem level.	No effect on site integrity anticipated

Table 9.3 North Norfolk Sandbanks and Saturn Reef SAC Assessment Matrix – Construction/Decommissioning

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning **Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning** **Potential Impact: Accidental pollution during construction/decommissioning**						
European Site	Qualifying Feature	Conservation Objective	Attributes	Conservation Objective target	Assessment overview/justification	Conclusion of effect on site integrity

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning						
North Norfolk Sandbanks and Saturn Reef SAC	Sandbanks which are slightly covered by sea water all the time	To ensure that, subject to natural change, the extent and distribution of qualifying habitats in the site are maintained or restored	Extent and distribution	Restore	A maximum of 9,305,800 m^2 temporary habitat loss/disturbance this is predicted to occur within Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from pre-construction sandwave clearance (and sandwave material deposition) and boulder clearance, cable installation including anchor placements). This represents 0.26% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC/Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the SAC (i.e. the entire SAC is assigned to the Annex I sandbank habitat, as it is designated and viewed as one integrated sandbank system; JNCC, 2010). The North Norfolk Sandbank is an open shelf ridge sandbank, formed by strong tidal currents, and the Conservation Objectives and Advice on Operations document for the site states that, in response to physical loss, the sandbank could be replenished and recovery relatively rapidly between removal activities The impact of temporary loss/disturbance to Annex I sandbanks within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, of medium term duration (i.e. construction phase of up to eight years, although export cable installation will only comprise a small proportion of this (up to three years)), intermittent in nature and reversible.	No effect on site integrity anticipated
		To ensure that, subject to natural change, the structure and function of the qualifying habitats in the site are maintained or restored	Physical structure: finer scale topography	Restore	Sandwave clearance material from sandwaves cleared within the North Norfolk Sandbanks and Saturn Reef SAC will be deposited within the same sandwave system within the boundary of the North Norfolk Sandbanks and Saturn Reef SAC. The precise disposal location selected will consider the net direction of sediment transport in the region to ensure that sediment will not be lost from the sandbank system (see section 1.11 in ES volume 1, chapter 1: Marine Processes). It is reasonable to assume a similarity of sediment particle size with depth through the sandwave on the basis of sediment transport processes, therefore, in most cases the deposited material is likely to be similar in nature to that present in the area in which it is deposited. Where sands are deposited into areas of different seabed type however (e.g. areas of slightly coarser seabed in some sandwave troughs), the seabed may become locally relatively finer in texture until the body of sand has been winnowed away or reincorporated into a bedform migrating over that location. In all cases, the deposited sediments would be rapidly incorporated into the seabed and local accumulations would be subject to redistribution under the prevailing hydrodynamic conditions.	No effect on site integrity anticipated
			Physical structure: sediment composition and distribution	Restore		

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning						
			Biological structure: key and influential species	Restore	Impacts will be localised and temporary in nature. With respect to ApriBatPo and NcirBat, these communities are naturally subject to, and tolerant of, high levels of physical disturbance. The predominantly infaunal mobile species are capable of re-burrowing following disturbance (Budd, 2008a; Tillin, 2016a and 2016e) although construction activities that remove sediment (e.g. seabed preparation) are likely to remove animals that are shallowly buried. Although resistance to abrasion/disturbance of the surface is none to low (medium for ApriBatPo; Tillin 2016e), as for example this could collapse burrows and damage species through compression, the resilience of these communities is assessed as high as sediment recovery will be enhanced by wave action and mobility of sand and the characterising species are likely to recover through transport of adults in the water column or migration from adjacent patches. Overall sensitivity to abrasion and disturbance is therefore considered to be low (Tillin, 2016a, 2016b and 2016e; Tillin and Rayment, 2016). The construction activities most likely to result in effects on Annex I 'Sandbanks which are slightly covered by seawater all the time' and Annex I reef habitats within the North Norfolk Sandbanks and Saturn Reef SAC from increased SSC and smothering are pre-construction sandwave clearance and export cable installation. The impact on these habitats is predicted to be of limited spatial extent, medium term duration (i.e. export cables installed over a period of four months to three years intermittent and reversible. Communities associated with 'Sandbanks which are slightly covered by seawater all the	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning Potential Impact: Accidental pollution during construction/decommissioning						
			Biological structure: characteristic communities	Restore	time' have low to no sensitivity to increased SSC and smothering because of deposition (Tillin, 2016b). These conditions are a natural feature of the environment in which these habitats occur. The sandy communities recorded in the Hornsea Three offshore cable corridor comprised biotopes that represent communities comprising low infaunal and epifaunal diversity, namely the NcirBat and ApriBatPo biotopes (see Figure 2.5 and volume 5, annex 2.1: Benthic Ecology Technical Report), in addition the biotope IMoSa has also been recorded at the sandbanks (Jenkins et al., 2015). The sandy communities associated with the sandbanks in this designated site are typically sparse and dominated by Bathyporeia spp. and Nephtys cirrosa (Jenkins et al., 2015). These taxa are considered to have a low sensitivity to increased SSC; the main impact being on the decreased light levels to diatoms which are a major food source of Bathyporeia spp. (Tillin, 2016b). Sandbank communities are not considered sensitive to light deposition (up to 5 cm of deposition in a single event) as the infauna are likely to be able to burrow through 5 cm of deposited sediment (Tillin, 2016b). The biotope ApriBatPo is determined to have a low sensitivity to both increased SSC and light deposition (Tillin, 2016e), increased SSC could reduce the availability of phytoplankton to the filter-feeding organisms, though the food supply would be quickly replenished from sources outside the ZoI of the impact, therefore moderating such effects (Tillin, 2016e). Light deposition would generally have limited effects on burrowing bivalves and polychaetes, though species adapted to sandy sediments may not be so effective at moving through finer, more cohesive sediments (Tillin, 2016e). With regards to the deposition of sandwave clearance material, although the deposition of this material may result in the mortality of characterising amphipods and isopods, and possibly *N. cirrosa*, biotope resistance is assessed as low but resilience is assessed as high.	No effect on site integrity anticipated
			Function	Recover	Considering the above the activites occuring during construction/decommissioning are not anticipated to impact on the ecological function (ecosystem services) of this feature of the site.	No effect on site integrity anticipated
		To ensure that, subject to natural change, the supporting processes on which qualifying habitats rely are maintained or restored	Hydrodynamic regime	Maintain	The proposed activities during construction/decommissioning do not represent a risk to natural physical energy resulting from waves, tides and other water flows.	No effect on site integrity anticipated
			Water quality	Maintain	The proposed activities during construction/decommissioning do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning **Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning** **Potential Impact: Accidental pollution during construction/decommissioning**						
			Sediment quality	Maintain	The proposed activities during construction/decommissioning do not represent a risk to impacts on sediment quality - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated
	Reefs (biogenic)	To ensure that, subject to natural change, the extent and distribution of qualifying habitats in the site are maintained or restored	Extent and distribution	Restore	Although the Hornsea Three offshore cable corridor coincides with the JNCC delineated boundary of *S. spinulosa* reef in the North Norfolk Sandbanks and Saturn Reef SAC, no Annex I reefs were identified during the site specific surveys of the Hornsea Three offshore cable corridor coinciding with the North Norfolk Sandbanks and Saturn Reef SAC. However, should Annex I *S. spinulosa* reef be identified in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be put in place to avoid direct impacts to these reefs. As such, figures are not presented for the temporary loss/disturbance of Annex I reef habitat as direct impacts to this habitat will be avoided.	No effect on site integrity anticipated
		To ensure that, subject to natural change, the structure and function (including typical species) of qualifying natural habitats are maintained or restored	Physical structure	Restore	As described above direct physical impacts to the feature will be avoided however it is noted that *S. spinulosa* reefs can recover their physical structure relatively quickly (within 16-24 months) from short-term or intermediate levels of physical impact/abrasion (Pearce et al., 2007; Gibb et al., 2014) and the evidence presented in the MarESA suggests that whilst *S. spinulosa* is sensitive to damage from siltation events recovery is likely to be rapid given that larval dispersal is not interrupted and new reefs may be able to establish over old buried ones (Tillin and Marshall, 2015).	No effect on site integrity anticipated
			Biological structure: key and influential species	Restore	As mentioned above impacts to established reefs will be avoided. The occurrence of Sabellaria biotopes throughout the Hornsea Three offshore cable corridor, together with other data such as the Humber REC dataset and the HADA MAREA dataset, indicates a wide distribution throughout this part of the southern North Sea. Considering the ephemeral nature of this species the proposed activities are not expected to alter the abundance and density of this species at a site/regional level. *S. spinulosa* is tolerant of increased SSC (Tillin and Marshall, 2015) and a limited amount of sediment deposition by fine sediment is likely to be well within the tolerance of *S. spinulosa*. As such, Annex I *S. spinulosa* reefs are not considered to be sensitive to increases in SSC.	No effect on site integrity anticipated
			Biological structure: characteristic communities	Restore		No effect on site integrity anticipated
			Function	Recover	Considering the above the activites occuring during construction/decommissioning are not anticipated to impact on the ecological function (ecosystem services) of this feature of the site.	No effect on site integrity anticipated
		To ensure that, subject to natural change, the supporting processes on	Hydrodynamic regime	Maintain	The proposed activities during construction/decommissioning do not represent a risk to natural physical energy resulting from waves, tides and other water flows.	No effect on site integrity anticipated

Potential Impact: Temporary habitat loss/disturbance during construction/decommissioning **Potential Impact: Temporary increases in suspended sediments/smothering during construction/decommissioning** **Potential Impact: Accidental pollution during construction/decommissioning**						
		which qualifying habitats rely are maintained or restored	Supporting habitats	Restore	See extent and distribution/Physical structure: The activities occurring during construction/decommissioning are tempory in nature and will not result in a baseline shift in the prevailing conditions including sediment type (grade) and the ability for future reef formation will not be impacted.	No effect on site integrity anticipated
			Water quality	Maintain	The proposed activities during construction/decommissioning do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated

Table 9.4: North Norfolk Sandbanks and Saturn Reef Assessment Matrix – Operation and Maintenance

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**						
European Site	Qualifying Feature	Conservation Objective	Attributes	Conservation Objective target	Assessment overview/justification	Conclusion of effect on site integrity

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance						
North Norfolk Sandbanks and Saturn Reef SAC	Sandbanks which are slightly covered by sea water all the time	To ensure that, subject to natural change, the extent and distribution of qualifying habitats in the site are maintained or restored	Extent and distribution	Restore	Up to 497,400 m^2 long term habitat loss is predicted to affect the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from cable protection where burial is not possible and pipeline/cable crossings). This represents 0.01% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. all potential Annex I sandbank habitat). Cable protection requirements along the Hornsea Three offshore cable corridor will be detailed in the Cable Specification and Installation Plan that will be agreed in consultation with statutory consultees. The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC. Hornsea Three will discuss and agree the most appropriate cable protection measures for the North Norfolk Sandbanks and Saturn Reef SAC, taking into account the local baseline environment. This may include measures which may encourage the burial of the scour/cable protection by the surrounding sediment or rock protection which takes into account the typical grain sizes (e.g. coarse gravel, cobbles and boulders) known to occur naturally within the SAC. Where such measures can be employed , these may allow local communities associated with the habitat features of the North Norfolk Sandbanks and Saturn Reef SAC (i.e. infaunal communities where sediment accumulation occurs; epifaunal in the case of appropriate rock protection) to colonise these areas, potentially providing some recovery of communities in areas where cable protection is placed and reducing the extent of long term habitat loss in the North Norfolk Sandbanks and Saturn Reef SAC.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance						
		To ensure that, subject to natural change, the structure and function of the qualifying habitats in the site are maintained or restored	Physical structure: finer scale topography	Restore	The proposed activities during operation/maintenance will not impact the hydrodynamics (currents) which influence the fine-scale topography of the sandbanks within the site (see hydrodynamics below).	No effect on site integrity anticipated
			Physical structure: sediment composition and distribution	Restore	Whilst the potential for the introdution of cable protection within the site would represent a change in the substratum for 0.01% of the site, the presence of this material would not alter the sediment composition or distribution of the wider sandbank system representing 99.99% of the site i.e sediment composition/distribution across crest/flank/trough of existing or future sanbanks (see extent and distribution above). Additionally, of the total temporary habitat disturbance loss predicted for Hornsea Three during operation and maintenance up to 2,790,300 m^2 of this is predicted to affect the Annex I 'Sandbanks which are slightly covered by seawater all the time' habitat within the North Norfolk Sandbanks and Saturn Reef SAC over the 25 year design life. This equates to 0.08% of the extent of this Annex I habitat within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. assuming all sediment within the SAC is assigned to Annex I sandbank habitat; JNCC, 2010). It was considered over precautionary and unrealistic to assume that all the temporary habitat disturbance within the Hornsea Three offshore cable corridor would occur entirely within this site, therefore it has been calculated on the assumption that, as approximately 29% of the total export cable length coincides with the North Norfolk Sandbanks and Saturn Reef SAC, 29% of the total operational temporary habitat loss along the Hornsea Three offshore cable corridor could occur within the site.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance
Potential Impact: Colonisation of hard structures during operation/maintenance
Potential Impact: Changes in physical processes during operation/maintenance
Potential Impact: Temporary seabed disturbance during operation/maintenance
Potential Impact: Accidental pollution during operation/maintenance

			Biological structure: key and influential species	Restore	The introduction of up to 544,123 m^2 of surface area of new hard substrate is predicted to occur because of the protection of export cables and cable/pipeline crossings within the North Norfolk Sandbanks and Saturn Reef SAC. Associated increases in biodiversity will potentially affect up to 0.015% of the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time'. In a habitat where encrusting epifaunal species are rare, this is likely to represent highly localised shifts in the baseline conditions. The introduction of hard substrate in the predominantly infaunal communities associated with the NcirBat, ApriBatPo and SspiMx biotopes has the potential to introduce species not typically present in these habitats to the area. The consequences, adverse or beneficial, are difficult to determine but the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' is deemed to be of low vulnerability. Designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will ensure that the risk of potential introduction and spread of INNS will be minimised. Subtidal mobile sandbanks are subject to continued reworking of the sediment by wave action and tidal streams and thus are dominated by species capable of tolerating severe changes in the hydro-physical regime (Elliott et al., 1998). The sandy communities recorded along the Hornsea Three offshore cable corridor within the North Norfolk Sandbanks and Saturn Reef SAC comprised biotopes that represent communities comprising low infaunal and epifaunal diversity, namely the NcirBat and ApriBatPo biotopes (see ES volume 5, annex 2.1: Benthic Ecology Technical Report), in addition the biotope IMoSa has also been recorded at the sandbanks (Jenkins et al., 2015). The sandy communities associated with	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance						
			Biological structure: characteristic communities	Restore	the sandbanks in this designated site are typically sparse and dominated by Bathyporeia spp. and Nephtys cirrosa (Jenkins et al., 2015). The NcirBat biotope is not sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016b). Mobile sands characterise this biotope and water movement is therefore an important physical parameter for this biotope, largely as wave action rather than tidal flow, however an increase in flow-related disturbance could shift the community assemblage to one characteristic of the IMoSa biotope, while a decrease can alter NcirBat to the FfabMag biotope (Tillin, 2016b). Similarly, the ApriBatPo biotope is not considered to be sensitive to local changes in tidal current flow or local changes in wave exposure (Tillin, 2016e). Characteristic species may be associated with troughs and crests of rippled bedforms which are created by the tidal flow and wave action, therefore this biotope may emerge following an increase in water flow, or disappear following a reduction in flow (Tillin, 2016e). The tidal currents across the former Hornsea Zone vary from approximately 0.6 ms-1 to 1 ms-1. ApriBatPo occurs in flow strengths of between <0.5 ms-1 and 1.5 ms-1, therefore the predicted maximum changes in current speeds resulting from Hornsea of +0.04 ms-1 to -0.1 ms-1 would be unlikely to cause the ApriBat biotope to disappear. Impacts arising from maintenance operations will be highly localised within the North Norfolk Sandbanks and Saturn Reef SAC with up to only 0.08% of Annex I habitat within the North Norfolk Sandbanks and Saturn Reef SAC affected and that the associated communities are predicted to recover rapidly from disturbance of this nature.	No effect on site integrity anticipated
			Function	Recover	Considering the above the activites occuring during operation & maintenance are not anticipated to impact on the ecological function (ecosystem services) of this feature of the site.	

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance						
		To ensure that, subject to natural change, the supporting processes on which qualifying habitats rely are maintained or restored	Hydrodynamic regime	Maintain	The presence of the turbine foundations and associated infrastructure also has the potential to affect the wave regime which could lead to potential impacts on offshore sandbanks including Annex I 'Sandbanks which are slightly covered by seawater all the time' within the North Norfolk Sandbanks and Saturn Reef SAC. The results of the wave modelling predict a general reduction in wave height in the region of the north Norfolk sandbanks when waves are coming from the north, north northeast and north east, which is about 15% of the time. During these conditions, there may be a small reduction in wave height of up to 15% within the vicinity of the Indefatigable Bank system and up to ~2% within the vicinity of sandbanks closer inshore (e.g. Ower Bank; see ES volume 5, annex 1.1: Marine Processes Technical Annex). Whilst impacts to sandbanks could theoretically occur throughout the operational lifetime (i.e. 25 years) of Hornsea Three (i.e. be of long term duration), any impacts would be intermittent in nature.	No effect on site integrity anticipated
			Water quality	Maintain	The proposed activities during operation & maintenance do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated
			Sediment quality	Maintain	The proposed activities during operation & maintenance do not represent a risk to impacts on sediment quality - Accidental pollution events will be mitigated against by means of industry standard practices.	No effect on site integrity anticipated
	Reefs (biogenic)	To ensure that, subject to natural change, the extent and distribution of qualifying habitats in the site are maintained or restored	Extent and distribution	Restore	Up to 497,400 m^2 long term habitat loss is predicted to occur within the North Norfolk Sandbanks and Saturn Reef SAC (i.e. from cable protection where burial is not possible and pipeline/cable crossings). This represents 0.01% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC. Cable protection requirements along the Hornsea Three offshore cable corridor will be detailed in the Cable Specification and Installation Plan that will be agreed in consultation with statutory consultees. The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a very small proportion of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC, with no predicted effects on existing Annex I reef habitats as direct imapcts to this feature will be avoided. Temporary disturbance to Annex I reef features within this site during maintenance operations will be avoided where possible to minimise any direct impacts and, based on the current distribution of habitats within the Hornsea Three offshore cable corridor, impacts to Annex I reef habitat are not predicted.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**						
		To ensure that, subject to natural change, the structure and function (including typical species) of qualifying natural habitats are maintained or restored	Physical structure	Restore	No impacts anticipated - see extent and distribution above	No effect on site integrity anticipated
			Biological structure: key and influential species	Restore	The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a small proportion of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC, with no predicted effects on qualifying Annex I reef habitats. The SspiMx biotope is not considered to be sensitive to INNS. However, designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the IMO ballast water management guidelines will, however, ensure that the risk of potential introduction and spread of INNS will be minimised.	No effect on site integrity anticipated
			Biological structure: characteristic communities	Restore	Increase in biodiversity associated with colonisation of hard structure (cable protection) is not predicted to affect any Annex I reef features of the North Norfolk Sandbanks and Saturn Reef SAC as no reefs were identified within the Hornsea Three benthic ecology study area coinciding with the North Norfolk Sandbanks and Saturn Reef SAC during the site specific surveys and should Annex I reef be present in the pre-construction survey within the North Norfolk Sandbanks and Saturn Reef SAC, appropriate measures will be put in place to avoid direct impacts to these reefs from cable protection.	No effect on site integrity anticipated
			Function	Recover	Considering the above the activites occuring during operation & maintenance are not anticipated to impact on the ecological function (ecosystem services) of this feature of the site.	

Potential Impact: Permanent habitat loss during operation/maintenance Potential Impact: Colonisation of hard structures during operation/maintenance Potential Impact: Changes in physical processes during operation/maintenance Potential Impact: Temporary seabed disturbance during operation/maintenance Potential Impact: Accidental pollution during operation/maintenance						
		To ensure that, subject to natural change, the supporting processes on which qualifying habitats rely are maintained or restored	Hydrodynamic regime	Maintain	*S. spinulosa* is tolerant of local changes in tidal current flow and local changes in wave exposure (Tillin and Marshall, 2015). As such, Annex I *S. spinulosa* reefs are not considered to be sensitive to these effects.	No effect on site integrity anticipated
			Supporting habitats	Restore	The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SAC is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, affecting a very small proportion of the seabed within the North Norfolk Sandbanks and Saturn Reef SAC, with no predicted direct effects on existing Annex I reef habitats as direct imapcts to this feature will be avoided. It is acknowledged that the presence of the cable protection within the North Norfolk Sandbanks and Saturn Reef SAC (representing 0.01% of the total area of the site) may serve as an ongoing barrier to the future establishment of Annex I reefs in those discrete areas. The MarESA for the SspiMx biotope does note, however, that *S. spinulosa* has been recorded colonising bedrock and artificial structures and an increase in the availability of hard substratum may, therefore, be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation, although the resulting biotope would be different (Tillin and Marshall, 2015). Therefore, it is not considered that the presence of cable protection within the North Norfolk Sandbanks and Saturn Reef SAC will preclude the establishment of Annex I reefs, or indeed Annex I 'Sandbanks which are slightly covered by seawater all the time' in these areas in the future.	No effect on site integrity anticipated

Potential Impact: Permanent habitat loss during operation/maintenance **Potential Impact: Colonisation of hard structures during operation/maintenance** **Potential Impact: Changes in physical processes during operation/maintenance** **Potential Impact: Temporary seabed disturbance during operation/maintenance** **Potential Impact: Accidental pollution during operation/maintenance**						
			Water quality	Maintain	The proposed activities during operation/maintenance do not represent a risk to impacts on water quality - Accidental pollution events will be mitigated against by means of industry standard practices	No effect on site integrity anticipated