Hornsea Project Three
Offshore Wind Farm

Hornsea Project Three Offshore Wind Farm

Preliminary Environmental Information Report: Draft Report to Inform Appropriate Assessment

Date: July 2017

Hornsea 3
Offshore Wind Farm

DONG energy

Habitat Regulations Assessment

Draft Report to Inform Appropriate Assessment

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DONG Energy Power (UK) Ltd.

5 Howick Place,

London, SW1P 1WG

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Prepared by: NIRAS Consulting Ltd

Checked by: Julian Carolan, Jenifer Brack, Allen Risby, Sophie Banham,

Accepted by: Sophie Banham

Approved by: Stuart Livesy

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Glossary

Term	Definition
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.
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).
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.

Term	Definition
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.
cable corridor	The specific corridor of seabed (seaward of Mean High Water Springs) and land (landward of Mean High Water Springs) 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 Mean High Water Springs) and land (landward of Mean High Water Springs) 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.
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 PEIR.
Hornsea Project Three	The third offshore wind farm project within the former Hornsea Zone. It has a maximum capacity of 2.4 GW (2,400 MW) and 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 PEIR.
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 PEIR.
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.

Term	Definition
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
CEFAS	Centre for Environment Fisheries and Aquaculture Science
CEA	Cumulative Effect Assessment
CoCP	Code of Construction Practice
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
GBF	Gravity base foundation
HDD	Horizontal Directional Drilling or other trenchless drill methods
HRA	Habitats Regulations Assessment
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee
LAeq,T	See “Equivalent continuous sound pressure level”.
LAmax	See “Maximum sound level”
LAT	Latitude

Acronym	Full Terminology
LA90	LA90 See "Background noise level".
LSE	Likely Significant effect
LTW	Lincolnshire Wildlife Trust
MM EWG	Marine Mammal Expert Working Group
MFE	Mass Flow Excavator
MMO	Marine Management Organisation
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
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
VSC	Voltage Source Converter
ZDA	Zone Development Agreement
ZEA	Zone Environmental Appraisal
WTG	Wind Turbine Generator

Units

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

1. Executive Summary

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 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 61 of the Habitats Regulations and Regulation 25 of the Offshore Habitats Regulations). The Appropriate Assessment must be carried out before consent or authorisation can be given for the project.

1.1.1.2 This draft Report to Inform Appropriate Assessment 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 conservation objectives (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 draft 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, where detailed information on the HRA screening exercise is provided and the Hornsea Three Preliminary Environmental Information Report (PEIR) and associated technical annexes.

1.1.1.6 This Draft 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 Report to Inform Appropriate Assessment will be updated and submitted as part of the Application for Development Consent. This document has been informed by the PEIR produced to date and will be subject to further discussion through the ongoing Evidence Plan process before final submission. The report is being issued alongside PEIR for consultation purposes. The Draft Report to Inform Appropriate Assessment will form the basis for Phase 2 Consultation which will commence on 27 July and conclude on 20 September 2017. At this point, comments received on the Draft Report to Inform Appropriate Assessment will be reviewed and incorporated (where appropriate) into the Report to Inform Appropriate Assessment, which will be submitted in support of the application for Development Consent scheduled for the second quarter of 2018.

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 of potential impacts potentially arising from the project and the ecology and distribution of qualifying features.

1.2.1.3 The HRA Screening Report (Annex 1) 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 SNCBs and other bodies, such as The Wildlife Trust and 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 relevant the 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 assessment in PEIR Chapters (PEIR Volume 2, Chapters 1 - 5) relevant to the Draft Report to Inform Appropriate Assessment .

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

1.3.2 Assessment of Adverse Effects on Site Integrity

Offshore Annex I habitats

1.3.2.1 The HRA Screening Report (Annex 1) identified the potential for an LSE on one site designated for offshore Annex I habitats:

- North Norfolk Sandbanks and Saturn Reef SCI.

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 this European site which, in summary, are to restore its qualifying features to favourable condition. The Annex I habitats that are qualifying features of this SCI that are screened into assessment comprise:

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

1.3.2.3 There is no indication, with respect to these Conservation Objectives, at this stage, 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 SCI is designated.

1.3.2.4 On this basis, there is no indication of an adverse effect on integrity on the North Norfolk Sandbanks and Saturn Reef SCI.

Annex II marine mammals

1.3.2.5 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).

1.3.2.6 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 which, in summary, are to maintain the distribution, extent and quality of habitats of the qualifying features within those sites and/or to restore them to favourable condition. 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.

1.3.2.7 With respect to these Conservation 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. Further analysis and assessment of the potential in-combination effect of disturbance arising from underwater noise during the construction phases will be undertaken for the harbour porpoise interest feature of the Southern North Sea cSAC.

Offshore bird features

1.3.2.8 The HRA Screening Report (Annex 1) identified the potential for an LSE on the following sites designated for offshore birds:

- Greater Wash pSPA; and
- Flamborough and Filey Coast pSPA / Flamborough Head and Bempton Cliffs SPA.

1.3.2.9 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 which, in summary, are to ensure that the integrity of the sites are maintained or restored as appropriate. The offshore species that are qualifying features of these European sites that are screened into assessment comprise:

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

1.3.2.10 With respect to these Conservation Objectives, there is no indication, at this stage, 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 the Greater Wash pSPA. Nor is there any indication that there will be an adverse effect on the puffin, razorbill and guillemot populations of the Flamborough and Filey Coast pSPA.

1.3.2.11 Whilst there is no indication that additional mortality of gannet and kittiwake arising from the project alone would lead to an adverse effect on those populations, further assessment of the in-combination effects on those breeding populations will be undertaken.

Onshore ecology

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

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

1.3.2.13 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 which, in summary, are to maintain the distribution, extent and quality of habitats of the qualifying features within those sites and/or to restore them to favourable condition.

1.3.2.14 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).

1.3.2.15 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.*

1.3.2.16 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.*

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

1.3.2.18 There is no indication, with respect to these Conservation Objectives, at this stage, that Hornsea Three, alone or in-combination with other plans and projects would adversely affect any of these onshore sites.

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 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 Draft Report to Inform Appropriate Assessment (and Annex 1 Hornsea Three Screening Report) as the former Hornsea Zone.

2.1.1.4 The first project to be proposed within the former Hornsea Zone was Project One. 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 Project One on 10 December 2014. The second project to be proposed within the former Hornsea Zone was Project Two. 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 offshore wind farm projects within the former Hornsea Zone, and the cable corridor and HVAC Search Area for Hornsea Three are shown in Figure 2.1.

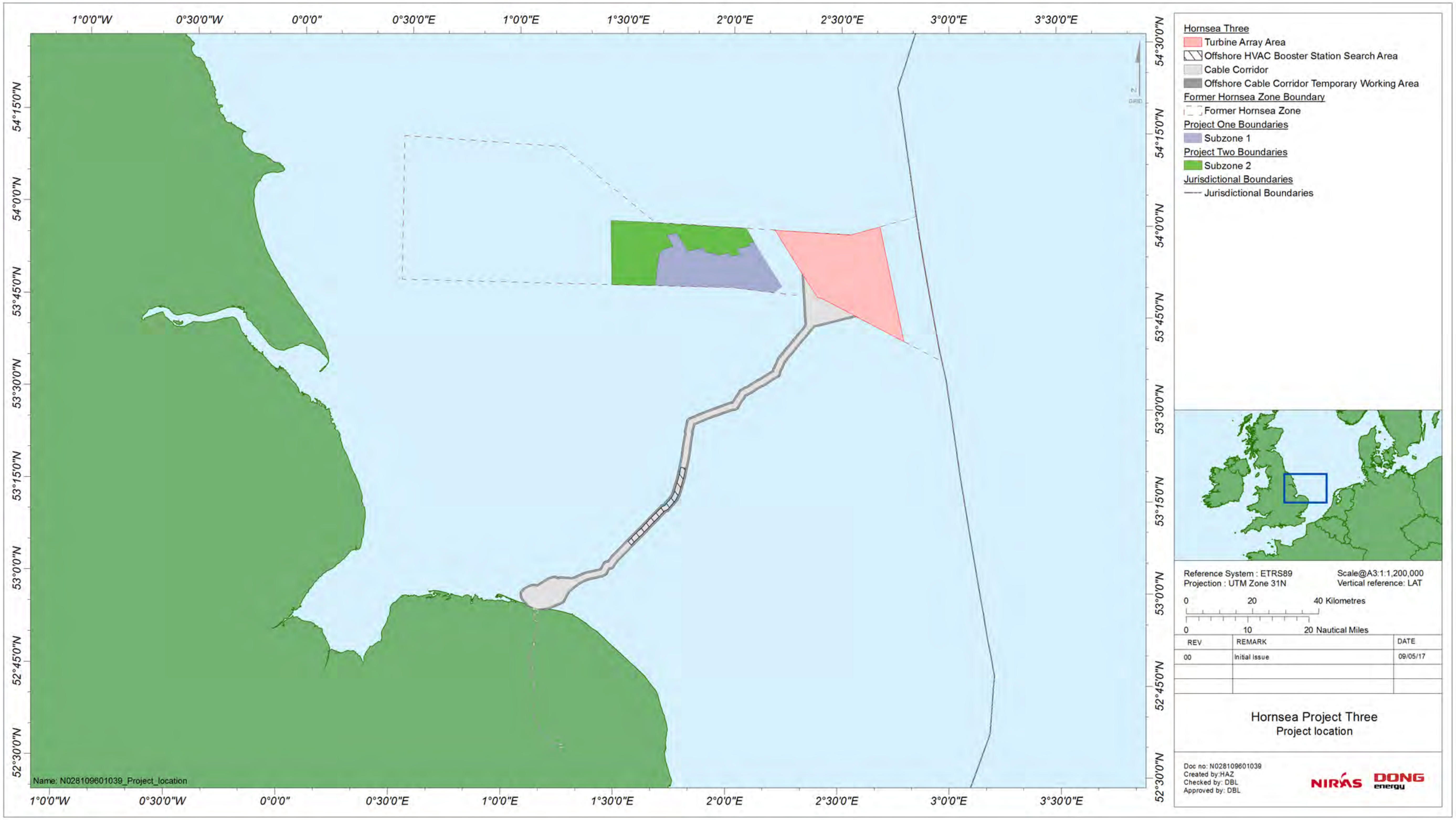

Figure 2.1: Location of the offshore wind farms within the former Hornsea Zone.

2.2 Hornsea Three offshore wind farm

2.2.1.1 Hornsea Three will have a total capacity of up to 2,400 MW and depending upon the size and model of turbine selected will include a maximum of up to 342 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 120 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 will be required if a HVAC transmission system is utilised and is located on the cable corridor. The onshore cable corridor search area is approximately 55 km in length, at its fullest extent.

2.2.1.3 Hornsea Three will have a maximum of 342 turbines, which will could supply up to 2.4 GW of power as measured at offshore metering point at the offshore substations. Hornsea Three will also have up to a total of up to 16 offshore substations (OSS) and up to three offshore accommodation platforms (OAP) 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 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.

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 stations.

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. Further details of the Hornsea Three design are provided in Section 3 (Project Overview).

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:

- Special Areas of Conservation (SACs/SCI) are designated under the Habitats Directive and promote the protection of flora, fauna and habitats; and
- Special Protection Areas (SPAs) are designated under the Birds Directive in order to protect rare, vulnerable and migratory birds.

2.3.1.2 Sites going through the formal designation process (i.e. candidate and proposed SACs (cSAC/pSAC)), Sites of Community Importance (SCIs) and potential SPAs (pSPA) 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.

2.3.1.3 For the purpose of this report European sites are defined as SACs, SCIs[1] and cSACs[2], 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.

2.3.1.4 Terrestrial areas of the UK and territorial waters out to 12 nautical miles (nm) are covered under The Conservation of Habitats and Species Regulations 2010.).

1 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.

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

2.3.1.5 The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 (the Offshore Habitats Regulations) (as amended) 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.

2.3.1.6 Combined, The Conservation of Habitats and Species Regulations 2010 and The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 are herein referred to as the "Habitats Regulations".

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 'Appropriate Assessment' (AA) must be undertaken by the Competent Authority (Regulation 61 of the Habitats Regulations and Regulation 25 of the Offshore Habitats Regulations). The Appropriate Assessment must be carried out before consent or authorisation can be given for the project[3].

2.3.2.2 The Planning Inspectorate (PINS) Advice note ten 'Habitat Regulations Assessment relevant to nationally significant infrastructure projects' (version 7, January 2016), defines HRA as a step by step process which determines likely significant effect (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).

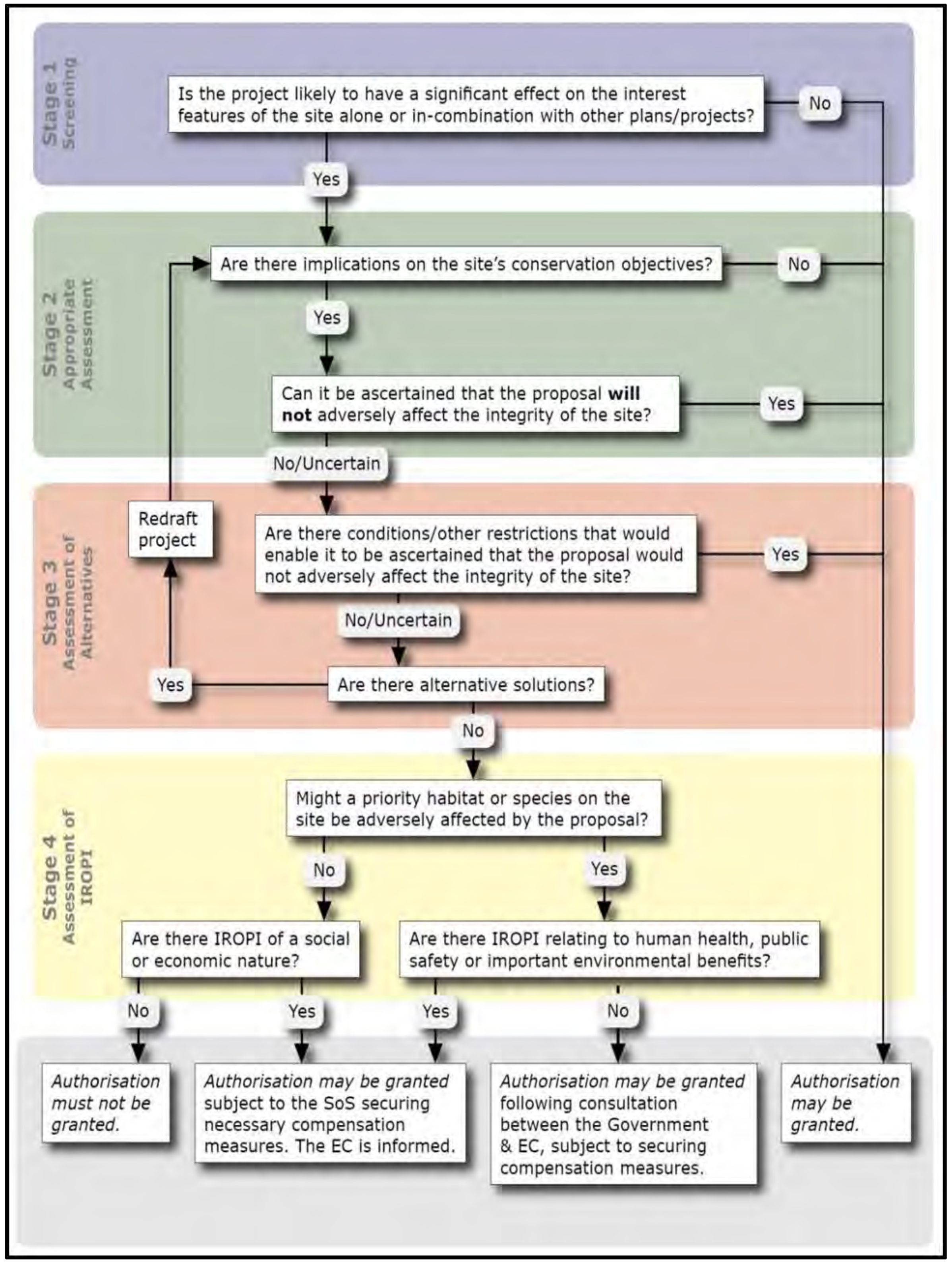

Figure 2.2: Four stage HRA process (The Planning Inspectorate 2016).

[3] Regulation 25(7) 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 an appointed person or a panel from 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 Draft Report to Inform the Appropriate Assessment produced for Hornsea Three will, in its final form, provide the information required by the Competent Authority to enable it to undertake an Appropriate Assessment, 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 Likely Significant Effect 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.

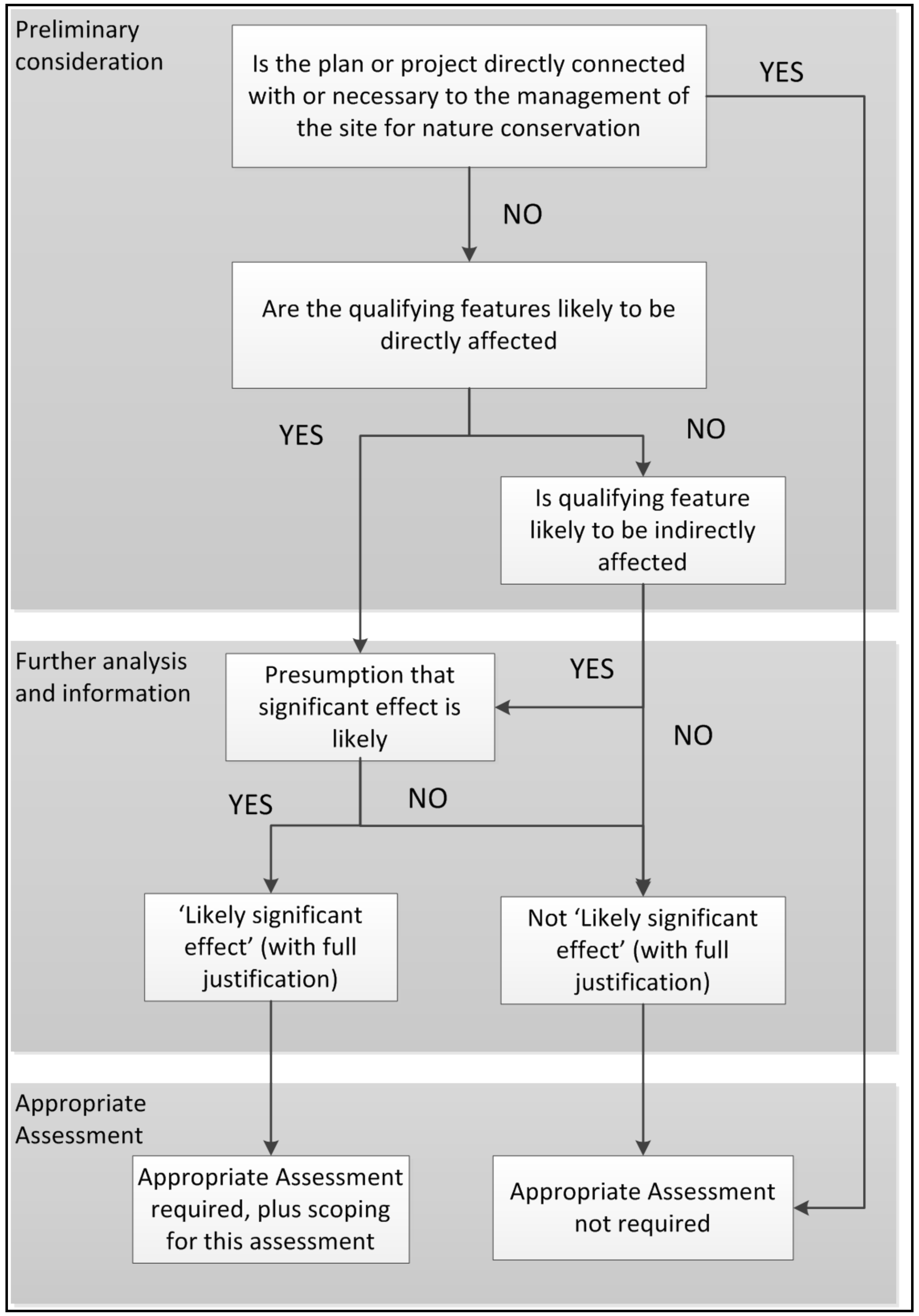

Figure 2.3: Step by step approach to determining LSE on a European site (adapted from HRGN 3).

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 Draft Report to Inform Appropriate Assessment. This Draft Report to Inform Appropriate Assessment 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 Draft Report to Inform Appropriate Assessment documents the assessment process undertaken to date in respect of Hornsea Three, for the purposes of the AA, and provides the information gathered to date 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.

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 Preliminary Environmental Information Report (PEIR Volume 2, Chapters 1-5). This document is structured as follows:

- Project overview describing key onshore, intertidal and subtidal components of Hornsea Three.
- Summary of screening exercise (Stage 1 of the HRA process; provided in full in Annex 01 – Hornsea Three 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; 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.

3. Project Overview

3.1 Introduction

3.1.1.1 This section of the Draft Report to Inform Appropriate Assessment provides an outline description of the potential current design envelope for of Hornsea Three, based on preliminary conceptual design information and current understanding of the environment from initial survey work. It sets out the Hornsea Three design and components for both the onshore and offshore infrastructure, as well as the activities associated with the construction, operation and maintenance, and decommissioning of the project.

3.1.1.2 At this stage in the Hornsea Three development, the project description (PEIR volume 1, chapter 3 project description) is indicative and the 'envelope' has been designed to include provide sufficient flexibility to accommodate further project refinement during detailed design. This section therefore sets out a series of options and parameters for which (unless noted otherwise) maximum values are shown. The maximum values constitute the realistic maximum design scenario in relation to Hornsea Three. The final design will be refined later in the project development from the parameters stated here. Hornsea Three will also, throughout the EIA process, seek to refine the proposed values and to provide more detailed realistic maximum design scenarios where required. A further refined and detailed project description will be provided in the final Report to Inform Appropriate Assessment and the Environmental Statement that will accompany the application for Development Consent.

3.2 Proposed Hornsea Project Three boundary

3.2.1.1 The proposed Hornsea Three boundary is illustrated in Figure 2.1 above. This area encompasses the:

- Hornsea Three array area: This is where the offshore wind farm will be located, which will include the turbines, wind turbine and offshore structure foundations, array cables, offshore accommodation platforms and a range of offshore substations as well as offshore interconnector cables and export cables;
- Hornsea Three offshore cable corridor: This is where the permanent offshore electrical infrastructure (offshore export cable(s), as well as the offshore HVAC booster substation(s) and their foundations, (if required), will be located; and
- Hornsea Three onshore cable corridor search area: This is where the permanent onshore electrical infrastructure (onshore export cable(s), as well as the onshore HVAC booster substation, (if required), onshore HVDC converter/HVAC substation and connections to the National Grid will be located.

3.3 The Agreement for Lease (AfL) area

3.3.1.1 The Agreement for Lease (AfL) from The Crown Estate (TCE) allows DONG Energy, as a prospective tenant of the AfL, to carry out investigations, such as survey activities, to identify the potential design within the Hornsea Three array area. It allows Hornsea Three to understand environmental sensitivities that may exist, in advance of submitting the consent application, whilst and before applying to TCE for a lease for the lifetime of the wind farm.

3.3.1.2 The AfL area for the Hornsea Three array area covers approximately 696 km^2 and is broadly a diamond shape with a length of approximately 29 km west to east and 35 km north to south. The AfL area is where the offshore infrastructure, such as the turbines, offshore substation(s) and array cables will be located. This area is hereafter referred to as the Hornsea Three array area throughout this chapter.

3.3.1.3 Hornsea Three does not yet have an AfL area for the offshore cable corridor. This will be applied for once an offshore cable corridor has been defined following initial survey and design work. Detail of the Hornsea Three offshore cable corridor AfL area will be published in the Environmental Statement.

3.4 Offshore infrastructure

3.4.1 Turbines

3.4.1.1 Hornsea Three plans to construct up to 342 wind turbines. A range of turbine models are under consideration for Hornsea Three; however, they all follow the traditional offshore wind turbine design with three blades and a horizontal rotor axis.

3.4.1.2 The maximum design scenario for turbines describes two scenarios, one with the largest number of turbines, using smaller parameters, and one with the largest turbine, using fewer turbines. The most numerous turbine scenario has a maximum of 342 turbines. The maximum size turbine has a rotor diameter of 265 m and a maximum blade tip height of 325 m relative to LAT (highest point of the structure). The minimum distance between the bottom of the blade and the water surface will be 34.97 m LAT. All turbines will be marked for aviation and navigation purposes.

3.4.1.3 The Environmental Statement will contain more detail on the turbine model options being considered but the decision on turbine selection will not have been made when the Environmental Statement is submitted, hence the environmental assessment will use a 'Design Envelope' to include the maximum design parameters to be assessed for environmental impact. The Design Envelope for Hornsea Three's wind turbines is shown

Table 3.1: Design Envelope - wind turbines.

Parameter	Maximum design scenario – Most Numerous Turbine	Maximum design scenario – Largest Turbine
Number of turbines	342	160
Minimum height of lowest blade tip above LAT (m)	34.97	34.97
Maximum blade tip height above LAT (m)	240	325
Maximum rotor blade diameter (m)	185	265

3.4.2 Foundations

3.4.2.1 The turbines, offshore substation(s) and offshore accommodation platform(s) are attached to the seabed by foundation structures or anchor systems. There are a number of foundation types that are being considered for Hornsea Three. Hornsea Three requires flexibility in foundation choice to ensure that anticipated changes in available technology and project economics can be accommodated within the Hornsea Three design. The final selection will depend on factors including turbine soil conditions, wave and tidal conditions, project economics and procurement approach. The range of foundation options to be used for turbines and each type of offshore substation can be seen in Table 3.2. The foundation types defined for turbines may also be used to support offshore substation structures or offshore accommodation platforms. However there are also a range of foundation types that are only intended to be used for specific offshore substation types. Consequently, a range of foundation types are considered, including monopiles, suction bucket jacket foundations, piled jacket foundations, mono suction buckets, gravity base structures and floating foundations.

3.4.2.2 Some form of seabed preparation may be required for each foundation type. Seabed preparations may include seabed levelling, and removing surface and subsurface debris such as (for example) boulders, lost fishing nets or lost anchors. If debris is present below the seabed surface, then excavation may be required for access and removal. Following consultation with the Marine Management Organisation and Ministry of Defence (MoD), any unexploded ordnance (UXO) found with a potential to contain live ammunition may be detonated on site and any remaining debris removed. However, as the location and number of UXO detonations is currently unknown and will not be known until the final design of Hornsea Three, it is not possible to assess the detonation of UXO until after consent is granted and the exact ground conditions are known. This activity (UXO detonation) will therefore not be screened in as part of the Draft Report to Inform Appropriate Assessment and a separate HRA and Marine Licence will be sought, if and when required.

Table 3.2: Foundation options for turbines and offshore structures.

	Turbine	Offshore transformer substation	Offshore HVAC booster station	Offshore HVDC converter substation	Offshore accommodation platform
Number of structures	342	12	4 [a] (6 subsea)	4*	3
Monopile	Y	Y	Y	Y	Y
Mono suction bucket	Y	Y	Y	Y	Y
Piled jacket	Y	Y	Y	Y	Y
Suction bucket jacket	Y	Y	Y	Y	Y
Gravity base	Y	Y	Y	Y	Y
Floating	Y	N	N	N	N
OSS suction bucket jacket	N	Y	Y	Y	Y
OSS piled jacket	N	Y	Y	Y	Y
Box-type gravity base	N	Y	Y	Y	N
Converter piled jacket	N	N	N	Y	N
Converter suction bucket jacket	N	N	N	Y	N
Pontoon GBS 1	N	N	N	Y	N
Pontoon GBS 2	N	N	N	Y	N

3.4.2.3 The foundations will be fabricated offsite, stored at a suitable port facility and transported to site as needed. Specialist vessels will be needed to transport and install foundations. A filter layer and/or scour protection layer (typically rock) may be needed on the seabed and will be installed either before and/or after foundation installation.

3.4.2.4 The Maximum Design Scenario for the sum (361) of the project foundations (342 for wind turbines and 19 for electrical infrastructure, comprising; 12 x offshore transformer substations, 4 x offshore converter substations and 3 x accommodation platforms) can be seen in Table 3.3.

3.4.2.5 The foundation types that will be considered in the Draft Report to Inform Appropriate Assessment are described in the following sections.

Table 3.3: Maximum design scenario for all project foundations.

Maximum design combined wind turbine, substation and accommodation platform foundations	Maximum design scenario
Total number of structures	361
Seabed area – preparation (m^2)	1,154,779
Seabed area – structure (m^2)	616,934
Seabed area – scour protection (m^2)	1,535,001
Seabed area – total (m^2)	2,116,108
Spoil volume (m^3)	2,459,850
Gravel bed volume (m^3)	1,732,169
Scour protection volume (m^3)	3,043,084
Pile-structure grout volume (m^3)	63,955
Structure-seabed grout volume (m^3)	313,769

Monopile foundations

3.4.2.6 Monopile foundations (MP) typically consist of a single steel tubular section, consisting of a number of sections of rolled steel plate welded together. A transition piece (TP) is fitted over the monopile and secured via bolts or grout. The transition piece may include boat landing features, ladders, a crane, and other ancillary components as well as a flange for connection to the wind turbine tower The TP is usually painted yellow and marked according to relevant regulatory guidance and may be installed separately following the monopile installation.

3.4.2.7 The Design Envelope for monopile foundations is shown in Table 3.4.

Table 3.4: Maximum design scenario: monopile foundations.

Parameter	Maximum design scenario
Diameter of monopile [a] (m)	15
Diameter of transition piece (m)	15
Embedment depth (below seabed) (m)	40
Hammer energy (kJ)	5,000

3.4.2.8 Monopiles and transition pieces will be transported to site either on the installation vessel (either Jack-up vessel (JUV) or Dynamic Positioning Vessel (DPV)), or on feeder barges. Monopiles can also be sealed and floated to site. Once on site, the monopiles will be installed using the following process:

- Lift monopile into the pile gripper on the side of the installation vessel;
- Lift hammer onto monopile and drive monopile into seabed to required embedment depth;
- Lift hammer from monopile and remove pile gripper;
- Lift transition piece onto monopile; and
- Secure transition piece onto monopile using either grout or bolts.

3.4.2.9 During the construction phase of Hornsea Three, up to four installation vessels may be in operation at any one time, usually operating over a 24 hour period, with up to two vessels piling simultaneously. The installation of a single monopile foundation may take up to three days allowing for vessel re-positioning and commissioning at each installation location, although continuous piling itself is anticipated to last for four hours. Piling always commences with low hammer energies ('soft start') and maximum hammer energies are used only where ground conditions require.

3.4.2.10 Seabed preparations for monopile installation are usually minimal. If preconstruction surveys show the presence of boulders or other seabed obstructions at foundation locations, these may be removed if the foundation cannot be re-sited to avoid the obstruction.

Piled jacket foundations

3.4.2.11 Piled jacket foundations are formed of a steel lattice construction (comprising tubular steel members and welded joints) secured to the seabed by hollow steel pin piles attached to the jacket feet. The piles rely on the frictional and end bearing properties of the seabed for support. Unlike monopiles, there is no separate TP. The TP and ancillary structure is fabricated as an integrated part of the jacket. Pin piles will typically be narrower than monopiles.

3.4.2.12 The maximum design scenario for jacket foundations with pin piles is shown in Table 3.5.

3.4.2.13 The installation of piled jackets is similar to that of monopiles, with the structures transported to site by installation vessels or barges and lowered onto the seabed by the installation vessel. The pin piles are driven, drilled or vibrated into the seabed, in a similar way to monopiles. However as pin piles are smaller, the maximum hammer energy to be used would be 2,500 kJ. There would be no more than two piles being driven simultaneously, and eight piles being drilled simultaneously across the Hornsea Three array area. The maximum duration for turbine foundation installation across the Hornsea Three array area would be 30 months.

Table 3.5: Maximum design scenario: jacket foundation with pin piles.

Parameter	Maximum design scenario
Number of legs per turbine	4
Separation of adjacent legs at seabed level (m)	40
Separation of adjacent legs at LAT (m)	25
Height of platform above LAT (m)	40
Leg diameter (m)	4.6
Pin pile diameter (m)	4
Embedment depth (below seabed) (m)	55
Hammer energy (kJ)	2,500

Suction bucket jacket foundations

3.4.2.14 Suction bucket jacket foundations are formed with a steel lattice construction (comprising tubular steel members and welded joints) fixed to the seabed by suction buckets installed below each leg of the jacket. The suction buckets are typically hollow steel cylinders, capped at the upper end, which are fitted in a horizontal position underneath the legs of the jacket structure. They do not require a hammer or drill for installation. Unlike monopiles, but similarly to piled jacket foundations, there is no separate TP. The TP and ancillary structure is fabricated as an integrated part of the jacket structure and is not installed separately offshore.

3.4.2.15 The maximum design scenario for suction jacket foundations with suction buckets is shown in Table 3.6.

Table 3.6: Maximum design scenario: jacket foundation with suction buckets.

Parameter	Maximum design scenario
Number of legs per turbine	4
Suction bucket diameter (m)	20
Suction bucket penetration (m)	20
Suction bucket height above seabed (m)	5
Separation of adjacent legs at seabed level (m)	40
Separation of adjacent legs at LAT (m)	25
Height of platform above LAT (m)	40

3.4.2.16 Once at site, the jacket foundation will be lifted by the installation vessel using a crane, and lowered towards the seabed in a controlled manner. When the steel caisson reaches the seabed, a pipe running up through the stem above each caisson will begin to suck water out of each bucket. The buckets are pressed down into the seabed by the resulting suction force. When the bucket has penetrated the seabed to the desired depth, the pump is turned off. A thin layer of grout is then injected under the bucket to fill the air gap and ensure contact between the soil within the bucket, and the top of the bucket itself. The vessel movements for the installation would be as for the monopile foundations.

3.4.2.17 As well as the boulder and obstruction removal that is described in the monopile section, the suction bucket jackets may also require some seabed levelling, to ensure that all the buckets for each structure can be placed at the same level, and that there is level ground beneath them to form a sealed chamber within the bucket once the foundation has been lowered to the seabed. The seabed levelling would likely be carried out by a dredging vessel using a suction hopper, and depositing the dredged material adjacent to the foundation location at site.

Mono suction bucket foundations

3.4.2.18 A mono suction bucket consists of a single suction bucket supporting a single steel or concrete structure, which supports the wind turbine. The installation method is similar to that described for the suction bucket jacket, and as with the jacket structures this foundation type does not require a TP to be installed offshore.

3.4.2.19 The maximum design scenario for this foundation type can be seen in Table 3.7 below.

Table 3.7: Design Envelope: mono suction bucket.

Parameter	Maximum design scenario
Suction bucket diameter (m)	40
Suction bucket penetration depth (m)	20
Suction bucket height above seabed (m)	10

3.4.2.20 The installation method is similar to that described for the suction bucket jackets except only a single bucket needs to be installed in the seabed. The vessel movements for the installation would be as for the monopile. The seabed preparation would be as described for the suction bucket jacket.

Gravity base foundations

3.4.2.21 Gravity base foundations are heavy steel, concrete, or steel and concrete structures, sometimes including additional ballast, that sit on the seabed to support the turbine tower. Gravity bases vary in shape, but are significantly wider at the base (at seabed level) to provide support and stability to the structure. They then generally taper to a smaller width at or below seabed level. They can either be brought to site on barges or installation vessels as for the other foundation types, or alternatively they can be floated to site. A gravity base does not require piling or drilling to remain in place. Scour protection is usually required to avoid the structure being undermined. The amount of ballast and scour protection will depend on structure design and location. Gravity base foundations need to be placed in pre-prepared areas of seabed. Seabed preparation would involve levelling and dredging of the soft mobile sediments as required, as well as any boulder and obstruction removal.

3.4.2.22 The maximum design scenario for gravity base foundations is shown in Table 3.8.

Table 3.8: Maximum design scenario: gravity base foundation.

Parameter	Maximum design scenario
External diameter at seabed (excluding scour protection) (m)	53
External diameter at LAT (m)	15
Seabed preparation diameter (m)	61
Scour protection diameter (m)	93

3.4.2.23 A gravity base does not require piling or drilling to remain in place. They can either be brought to site on barges or installation vessels as for the other foundation types, or alternatively they can be floated to site. This would be done by designing the structures to be buoyant, and towing them to site using tugs and support vessels. The foundations would then be lowered to the seabed in a controlled manner either by pumping in water, or installation of ballast (or both).

3.4.2.24 Gravity base foundations need to be placed in pre-prepared areas of seabed. Seabed preparation would involve levelling and dredging of the soft mobile sediments as required, as well as any boulder and obstruction removal. It is likely that dredging would be required if using the gravity base foundations. If dredging is required it would be carried out by dredging vessels using suction hoppers or similar, and the spoil would be deposited on site adjacent to the turbine locations. The seabed preparation would be as described for the suction bucket jacket.

Floating foundations

3.4.2.25 Floating foundations can consist of a range of structure types, typically classed as spar buoys, tensioned-leg platforms or semi-submersibles. This classification depends on how stability is achieved; by ballast at the base of the spar, by tension in the mooring lines or by a wide structure at the water surface. Typically the structure will consist of either a single slender vertical cylindrical structure, called a spar buoy, or a shallower and more complex structure consisting of various tubular and plate elements, called a tensioned-leg platform or semi-submersible platform.

3.4.2.26 The foundations are typically fabricated from steel and/or concrete and are held in place by mooring lines connected to anchors in the seabed. The anchors could be piles, suction buckets, gravity structures or drag anchors. The structures will either be floated into place from harbour or brought to site on suitable installation vessels and lifted into the water. The anchors will be installed using a range of methods dependent on the anchor type, including piling, drilling, suction, and placement. The installation of the anchors is likely to be carried out by a separate vessel.

3.4.2.27 The Design Envelope for floating foundations is shown in Table 3.9.

Table 3.9: Maximum design scenario: floating foundation.

Parameter	Maximum design scenario
Foundation surface dimension (m)	75
Depth of structure (m)	50
Number of mooring lines and anchors (per turbine)	12
Mooring cable radius (m)	1,000
Maximum anchor height (above seabed) (m)	7.5

3.4.2.28 The structures will either be floated into place from harbour or brought to site on suitable installation vessels and lifted into the water. The anchors will be installed using a range of methods dependent on the anchor type, including piling and drilling if piles are used, or suction, and placement if gravity, suction or drag anchors are used (the impacts of these techniques would sit inside the maximum design scenario outlined in Table 3.3). The installation of the anchors is likely to be carried out by a separate vessel.

Foundation types for offshore substations and offshore accommodation platforms

3.4.2.29 Although all the foundation options available for turbines (excluding floating foundations) may also be used for offshore substations (OSS) and offshore accommodation platforms (OAP), there are some foundation designs that could be used for OSS and OAP but will not be used for supporting turbines. The descriptions of these foundations are outlined below.

OSS piled jacket

3.4.2.30 This foundation type is a larger variant of the piled jacket option to be used for turbines. These foundations may also require the use of mud-mats, which are flat plates attached to the bottom of the jacket legs to support the foundation structure before piles are installed (if piles are installed after the jacket). The parameters for the OSS piled jacket foundation can be seen in Table 3.10 below.

Table 3.10: Maximum design scenario: OSS piled jacket.

Parameter	Maximum design scenario
Number of legs per jacket	6
Piles per leg	4
Separation of adjacent legs at seabed level (m)	70
Separation of adjacent legs at LAT (m)	70
Height of platform above LAT (m)	40
Leg diameter (m)	5
Pin pile diameter (m)	4
Pile height above seabed (m)	20
Mud-mats length and width [m]	10
Embedment depth (below seabed) (m)	70
Hammer energy (kJ)	2,500

OSS suction bucket jacket

3.4.2.31 This foundation type is a larger variant of the suction bucket jacket option to be used for turbines. The parameters for the OSS suction bucket jacket foundation can be seen in Table 3.11 below.

Table 3.11: Maximum design scenario: OSS suction bucket jacket

Parameter	Maximum design scenario
Number of legs per platform	6
Suction bucket diameter (m)	25
Suction bucket penetration (m)	25
Separation of adjacent legs at seabed level (m)	70
Separation of adjacent legs at sea surface (m)	70
Height of platform above LAT (m)	40

Box type gravity base

3.4.2.32 This foundation type is a variant of the gravity base foundation, however rather than having a circular base to support a single tower, this type of foundation has a square base that supports the steel or concrete supporting structure for the substation topsides. The parameters for the box type gravity base foundation can be seen in Table 3.12 below. This foundation type will not be used for OAPs.

Table 3.12: Maximum design scenario: Box type gravity base.

Parameter	Maximum design scenario
Length and width at seabed level (m)	75
Length & and width at LAT (m)	75
Seabed preparation buffer around base (m)	50
Seabed preparation buffer below base (m)	-1
Length & Width of seabed preparation area (m)	175

Foundation types for offshore HVDC converter stations

3.4.2.33 Although all the foundation options available for turbines (excluding floating foundations), OSS and OAP may also be used for offshore HVDC converter substations, there are some foundation designs that could be used for offshore HVDC converter substations but are not intended to be used for supporting other offshore infrastructure. The descriptions of these foundations is outlined below.

Converter piled jacket

3.4.2.34 This foundation type is a larger variant of the piled jacket option to be used for turbines. The offshore HVDC converter stations could each be supported by four jacket structures, or a single larger jacket. The parameters for the converter piled jacket can be seen in Table 3.13 below.

Table 3.13: Maximum design scenario: converter piled jacket

Parameter	Maximum design scenario
Number of jackets per platform	4
Number of legs per platform	18
Piles per leg	4
Separation of adjacent legs at seabed level (m)	100
Separation of adjacent legs at LAT (m)	100
Pin pile diameter (m)	3.5
Pile penetration (m)	70
Mud-mats length and width (m)	20
Hammer energy (kJ)	2,500

Converter suction bucket jacket

3.4.2.35 This foundation type is a larger variant of the suction bucket jacket option to be used for turbines. The parameters for the converter suction bucket jacket can be seen in Table 3.14 below.

Table 3.14: Maximum design scenario: converter suction bucket jacket.

Parameter	Maximum design scenario
Number of jackets per platform	4
Number of legs (per jacket)	6
Suction bucket diameter (m)	20
Suction bucket penetration (m)	30

Pontoon gravity base – type 1

3.4.2.36 This foundation type is a variant of the gravity base foundation, however rather than having a circular base to support a single tower, this type of foundation has up to three rectangular pontoons that support the steel or concrete supporting structure for the substation topside. The parameters for the pontoon gravity base – type 1 can be seen in Table 3.15 below.

Table 3.15: Maximum design scenario: pontoon gravity base – type 1.

Parameter	Maximum design scenario
Number of pontoons per platform	3
Pontoon length (m)	170
Pontoon width (m)	35
Pontoon spacing (m)	36
Pontoon base width (m)	90

Pontoon gravity base – type 2

3.4.2.37 This foundation type is a variant of the gravity base foundation, however rather than having a circular base to support a single tower, this type of foundation has a pontoon, arranged in a rectangle around an open centre, that supports the steel or concrete supporting structure for the substation topside. The parameters for the pontoon gravity base - type 2 can be seen in Table 3.16 below.

Table 3.16: Maximum design scenario: pontoon gravity base – type 2.

Parameter	Maximum design scenario
Number of pontoons per platform	1
Pontoon length (m)	120
Pontoon width (m)	35

Scour protection for foundations

3.4.2.38 Scour protection is designed to prevent foundation structures for turbines, substations and offshore accommodation platforms, being undermined by hydrodynamic and sedimentary processes, resulting in seabed erosion and subsequent scour hole formation. The shape of the foundation structure is an important parameter influencing the potential depth of scour hole formation. Scour around foundations is typically mitigated by the use of scour protection measures. Several types of scour protection exist, including mattress protection, sand bags, stone bags and artificial seaweeds. However, the placement of large quantities of crushed rock around the base of the foundation structure is the most frequently used solution ('rock placement').

3.4.3 Array cables

3.4.3.1 Cables carrying the electrical current produced by the wind turbine generators will link the wind turbines to an offshore substation. A small number of turbines will typically be grouped together on the same cable 'string' connecting those turbines to the substation, and multiple cable 'strings' will connect back to each offshore substation.

3.4.3.2 It is likely the array cable system will use HVAC technology, but it is also possible that the system will consist of [a more novel technology] an alternative option such as a HVDC or low frequency HVAC array cable system.

3.4.3.3 The array cables will consist of a number of conductor cores, usually made from copper or aluminium surrounded by layers of insulating material, as well as material to armour the cable for protection from external damage, and material to keep the cable watertight.

3.4.3.4 The maximum design scenario for array cables is shown in Table 3.17.

Table 3.17: Maximum design scenario: array cables.

Parameter	Maximum design scenario
Cable diameter (mm)	200
Total length of cable (km)	850
Voltage (kV)	170

3.4.3.5 The installation method and target burial depth will be defined post consent based on a cable burial risk assessment (CBRA) taking into account ground conditions as well as external aggressors to the cable such as trawling and vessel anchors. This depth will likely vary across the Hornsea Three array area. Possible installation methods include jetting, vertical injection, cutting and ploughing whereby the seabed is opened and the cable laid within the trench simultaneously using a tool towed behind the installation vessel. Alternatively, a number of these operations such as jetting, cutting or Mass Flow Excavation (MFE) may occur post cable lay. It may also be necessary to install the cable by pre-trenching or rock cutting whereby a trench is opened in one operation and then the cable laid subsequently from another vessel. Hornsea Three may also need to dredge the cable route prior to installation in order to level sandwaves that may hinder installation.

3.4.3.6 The cables will be buried below the seabed wherever possible. If the array cables must cross third party infrastructure such as existing cables both the third party asset and the installed cable must be protected. This protection would usually consist of a rock berm on the existing cable (separation layer), as well as a second rock berm on the cable installed for Hornsea Three (protection layer). The detailed design of the crossing would be decided in a crossing agreement developed by both parties.

3.4.3.7 The maximum design scenario for array cable installation can be seen in Table 3.18.

Table 3.18: Maximum design scenario: array cable installation.

Parameter	Maximum design scenario
Installation methodology	Trenching, dredging, jetting, ploughing, mass flow excavation, vertical injection, rock cutting
Burial depth	Typically 1-2m. Dependent on CBRA[a]
Width of seabed affected by installation per cable (m)	10
Width of seabed affected by sandwave clearance (where required) per cables (m)	30
Total seabed disturbed (km^2)	8.5
Seabed disturbance (m^2)	8,500,000
Burial spoil: jetting (m^3)	1,878,500
Burial spoil: ploughing/mass flow excavation (m^3)	5,100,000
Duration: per cable (days)	3
Duration: total (months)	30

a Typically the cable will be buried between 1 - 2m. A Cable Burial Risk Assessment (CBRA) will inform cable burial depth, dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent.

Sandwave Clearance

3.4.3.8 In some areas within the Hornsea Three array (AfL area) and offshore cable corridor, existing sandwaves (including similar smaller-scale migratory bedforms such as megaripples) and boulders may be required to be removed before cables are installed. This is done for two reasons. Firstly, many of the cable installation tools require a relatively flat seabed surface in order to work properly. It may not be possible to install the cable up or down a slope over a certain angle, as well as if the installation tool is working on a camber. Secondly, the cable must be buried to a depth where it may be expected to stay buried for the duration of the Hornsea Three project lifetime. Sandwaves are generally mobile in nature therefore the cable must be buried beneath the level where natural sandwave movement would uncover it. Sometimes this can only be done by removing the mobile sediments before installation takes place.

3.4.3.9 If required, this sandwave clearance would require dredging using a suction dredger or similar. Any sediment removed would be disposed of within the local sandwave field (Table 5.1).

3.4.4 Offshore accommodation platforms

3.4.4.1 Hornsea Three may construct up to three offshore accommodation platforms to allow up to 150 operations staff to be housed at the Hornsea Three array area for several weeks at a time, and to allow spares and tools to be stored at the Hornsea Three array area. This aims to reduce trips to the Hornsea Three array area and time spent in transit, to decrease down time for faults and repairs. The offshore accommodation platforms would be accessed by vessel and/or helicopter, and may have associated captive vessels to access the turbines and substations. All offshore accommodation platforms would be located in the Hornsea Three array area.

3.4.4.2 The maximum design scenario for the offshore accommodation platforms can be seen in Table 3.19 below. The offshore accommodation platforms may also be co-sited with offshore substations, including bridge access between the two platforms. The offshore accommodation platforms would use the same substructure and foundation concepts as the turbines and offshore substations (excluding box type gravity base foundations).

Table 3.19: Maximum design scenario: offshore accommodation platforms.

Parameter	Maximum design scenario
Number	3
Length and width (m)	60
Main structure height above LAT (m)	60
Structure height max above LAT (m)	64
Foundation type	As for turbines or offshore substations (excluding box type gravity base).
Installation	As for offshore substations in Section 3.4.6

3.4.4.3 The installation procedure would be as described for the offshore transformer substations.

3.4.5 Transmission system

3.4.5.1 The wind farm transmission system is used to transport the power produced at the turbines and delivered by the array cables, to the UK National Grid. The system transforms the Medium Voltage (MV) power produced at the turbines to HV at the offshore transformer substations (located in the Hornsea Three array area), and transports this via export cables and a number of other offshore and onshore components. The transmission system is usually designed, paid for and constructed by the wind farm developer (DONG Energy in the case of Hornsea Three), but must be purchased by an Offshore Transmission Operator (OFTO) after the wind farm is constructed in a transaction overseen by the Office of Gas and Electricity Markets (Ofgem). It is also possible that the transmission asset may be designed, procured and installed by the OFTO, however the design and installation parameters would still be consented through this application.

Project capacity

3.4.5.2 The point at which the energy produced by the wind farm is metered is at the offshore substation (currently MV side of the transformer), therefore all wind farm capacities defined through the consenting process will be in reference to the capacity at the MV side of the offshore substations. Hornsea Three has a planned maximum export capacity of 2.4 GW. The total capacity of the turbines themselves may exceed 2.4 GW in order to compensate for electrical losses in the array cables, as well as for turbines shut down for maintenance. However, the total number and physical dimensions of turbines would not exceed that stated within this chapter. Hornsea Three may be split into and constructed in up to three phases. The phases may be constructed either separately or together (see Section 3.6).

HVAC/HVDC transmission systems

3.4.5.3 There are a range of transmission system designs that can be used to transport the power from the Hornsea Three array area to the UK National Grid. These fall under two primary transmission types defined by how the current is delivered to the export cables; HVAC or HVDC. Both transmission types have a range of relative benefits and drawbacks. Offshore wind farms have traditionally used HVAC connections; however, HVDC connections become more technically and/or economically viable in the context of far from shore projects and are used on a number of projects in Germany. Hornsea Three requires flexibility in transmission system choice to ensure that anticipated changes in available technology and project economics can be accommodated within the Hornsea Three design, and will make a decision on which transmission type to use during the detailed design phase (post consent).

3.4.5.4 An overview of the differences between the component requirements between two technologies are outlined in Table 3.20.

Table 3.20: Infrastructure required for High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) systems.

Component	HVAC	HVDC	Comment
Offshore transformer substation	Y	M	HVDC: may be combined with converter substation
Offshore interconnector cable	M	M	Interconnector cables may be required between offshore substations.
Offshore converter substation	N	Y	-
Offshore export cable	Y	Y	-
Offshore HVAC booster substation(s)	M	N	HVAC: onshore and/or offshore HVAC booster substation required.
Onshore HVAC booster substation	M	N	
Onshore export cable	Y	Y	-
Onshore HVDC converter/HVAC substation	Y	Y	HVDC systems require larger onshore converter substations for conversion to HVAC.
Grid connection export cable	Y	Y	-
Table Key	*Required (Y)*	*May be required (M)*	*Not required (N)*

3.4.6 Offshore substations

3.4.6.1 Offshore substations are offshore structures housing electrical equipment to provide a range of functions, such as changing the voltage (transformer substations), current type (converter substations) or power factor of the power (Offshore HVAC booster substations,). Each of the different offshore substation types is detailed below. All offshore substations will be marked, as with the turbines, for aviation and navigation purposes. The exact substation locations will be determined during the wind farm design phase (typically post consent), taking account of ground conditions and the most efficient cable routing amongst other considerations. Offshore substations will not be manned but once functional will be subject to periodic operational and maintenance visits by staff deployed by helicopter, by vessel or from a nearby accommodation platform.

3.4.6.2 Hornsea Three requires flexibility in location and foundation choice of offshore transformer substations to ensure anticipated changes in available technology and project economics can be accommodated within the Hornsea Three design.

3.4.6.3 A description of the offshore substations is provided below.

Offshore HVAC transformer substation

3.4.6.4 Offshore Transformer Substations are required in HVAC transmission systems and may be required in HVDC transmission systems, dependent on the system design.

3.4.6.5 One or more offshore transformer substations will collect the electricity generated by the operational turbines via the array cables. The voltage will be "stepped up" by transformers on the substation before transmission to the onshore HVDC converter/HVAC substation by export cables; this will be via the offshore converter substation in the case of the HVDC transmission option, or the offshore and/or onshore HVAC booster substation(s) in the case of the HVAC transmission option.

3.4.6.6 All offshore transformer substations would be located within the Hornsea Three array area.

3.4.6.7 The HV equipment on the offshore transformer substations is expected to be rated between 220 kV and 400 kV. The substation unit is pre-fabricated in the form of a multi-layered cube and will be mounted on a foundation some distance above the sea surface.

3.4.6.8 Up to 12 separate offshore transformer substations could be required. All offshore transformer substations will be located within the final wind farm array area.

3.4.6.9 The maximum design scenario for offshore transformer substation is shown in Table 3.21.

Table 3.21: Maximum design scenario: offshore transformer substations.

Parameter	Maximum design scenario
Number of offshore transformer substations	12
Topside – main structure length and width (m)	90
Topside – ancillary structure length and width (m)	100
Topside – height (excluding helideck or lightning protection) (LAT) (m)	70
Height of lightning protection & ancillary structures (LAT) (m)	90
Topside - area (m^2)	8,100
Topside (inc. ancillaries) area (m^2)	10,000
Transformer oil - per substation (kg)	200,000
Diesel Fuel – per substation (l)	50,000
SF6 – per substation (kg)	1,500
Batteries (lead acid gel) – per substation (kg)	6,000

3.4.6.10 Offshore transformer stations are generally installed in two phases, the first phase will be to install the foundation for the structure using an installation vessel, secondly an installation vessel (same or different from the one installing the foundation) will be used to lift the topside from a transport vessel/barge, onto the pre-installed foundation structure. The foundation and topside may be transported on the same transport vessel/barge, or separately. The foundation may also be transported by the installation vessel.

Offshore HVDC converter substations

3.4.6.11 Offshore HVDC converter substations are required in HVDC transmission systems only; they are not required in HVAC transmission systems. Offshore HVDC converter substations convert the three-phase AC power generated at the turbines into DC power. This is then transmitted to the onshore HVDC converter/HVAC substation via the export cables.

3.4.6.12 As for the offshore transformer substations, the offshore converter substation unit is pre-fabricated in the form of a multi-layered cube. The offshore HVDC converter substation is expected to be larger than the offshore transformer substations, due to the differing power electronics it would contain. The structure will most likely be mounted on a jacket or gravity base foundation some distance above the sea surface. Up to four separate offshore HVDC converter substations will be required. The maximum design scenario for this can be seen in Table 3.22.

Table 3.22: Maximum design scenario: offshore converter substations.

Parameter	Maximum design scenario
Number of offshore converter substations	4
Length of topside (m)	180
Width of topside (m)	90
Topside area (m^2)	16,200
Topside - height (excluding helideck or lightning protection) (LAT)	100
Height of lightning protection above topside (LAT)	110
Diesel fuel (l)	200,000

3.4.6.13 Hornsea Three requires flexibility in location and foundation choice of the offshore convertor substations to ensure that anticipated changes in available technology and project economics can be accommodated within the Hornsea Three design.

3.4.6.14 It is possible that the design approach for offshore converter substations will move towards multiple smaller units, rather than fewer large units. In this case the Design Envelope for the smaller offshore transformer substations (as in Table 3.21) should be used, however the total number of offshore transformer substations would be up to 12 and up to four offshore HVDC converter substations, not exceeding 16 in total.

3.4.6.15 Dependent on the design of the offshore HVDC converter substations, installation may be as for the offshore transformer substations. alternatively a ‘float-over’ installation may be used. This type of installation, usually used with gravity base structures, however it may also be advantageous to pre-assemble the topside and foundation in the fabrication yard or staging port, and float the whole substation structure to site in a single trip.

Offshore HVAC booster station(s)

3.4.6.16 Offshore HVAC booster station(s) are required in HVAC transmission systems only; they are not required in HVDC transmission systems.

3.4.6.17 Long distance, large capacity HVAC transmission systems require reactive compensation equipment to reduce the reactive power generated by the capacitance of the export cable in order to allow the power delivered to the National Grid to be useable. The electrical equipment required to provide the reactive compensation, in the form of an HVAC booster substation, can be located onshore, on an offshore platform, or within a subsea structure. Alternatively a combination of these options could be used. If required, this infrastructure would be located in the Hornsea Three offshore cable search area, rather than in the array area.

Surface

3.4.6.18 Although the different substations perform different functions, and contain differing internal electrical equipment, the external design of a surface offshore HVAC booster station will be very similar to the offshore transformer substations. The maximum design envelope is shown in Table 3.23. Installation will be as for the offshore transformer substations.

Table 3.23: Maximum design scenario: surface offshore HVAC booster.

Parameter	Maximum design scenario
Number of surface offshore HVAC booster stations	4
Topside – main structure length and width (m)	90
Topside – ancillary structure length and width (m)	100
Topside – height (excluding helideck or lightning protection) (LAT) (m)	70
Height of lightning protection above topside (LAT) (m)	90
Transformer/reactor oil (kg)	225,000
Diesel Fuel (l)	20,000
SF6 (kg)	1,500
Batteries (lead acid gel) (kg)	6,000

Subsea

3.4.6.19 Although this technology is known to be being developed by the supply chain, at the time of writing no subsea offshore HVAC booster substation(s) have been constructed for HV power transfer, therefore the details of this type of structure are primarily based on knowledge of surface designs as well as an understanding of subsea structures used in the offshore oil and gas industry. The structure would likely be a sealed steel or concrete structure, similar to the topside of an offshore substation but fixed to the seabed with piles, and without any substructure required to lift it above the sea surface. It is not expected that this structure would be regularly accessed for operation and maintenance during Hornsea Three's lifetime. The maximum design scenario can be seen in Table 3.24.

Table 3.24: Maximum design scenario: subsea offshore HVAC booster station(s).

Parameter	Maximum design scenario
Number of subsea offshore HVAC booster stations	6
Subsea structure: length (m)	50
Subsea structure: width (m)	50
Subsea structure: height above seabed (m)	15
Subsea structure: number of piles per substation	12
Piles: penetration depth (m)	50
Piles: diameter (m)	2

3.4.6.20 The exact installation procedure for subsea offshore HVAC booster substation(s) is currently unknown, however it is likely that the structure will be preassembled at the fabrication yard and brought to site by either on a barge or on the installation vessel. The installation vessel will then lower the structure to the seabed and secure the structure to the seabed with piles either installed in advance or afterwards.

3.4.7 Offshore export cables

3.4.7.1 Offshore export cables are used for the transfer of power from the offshore substations to the landfall point. For HVAC transmission systems offshore export cables will carry electricity from the offshore transformer substations to the offshore HVAC booster substation(s) and then on to the landfall. For HVDC transmission systems, offshore export cables will carry electricity from the offshore transformer substations to the offshore converter substations and then to the landfall. Up to six offshore export cables, with a voltage of up to 600 kV will be required for Hornsea Three. If possible the cables will be buried below the seabed through to landfall.

3.4.7.2 Hornsea Three requires flexibility in type, location, depth of burial and protection measures for export cable to ensure that anticipated physical and technical constraints and changes in available technology and project economics can be accommodated within the Hornsea Three design.

3.4.7.3 Like the array cables, the export cables will consist of a number of conductor cores, usually made from copper or aluminium. These will be surrounded by layers of insulating material as well as material to armour the cable for protection from extremal damage and material to keep the cable watertight. Export cables are however typically larger in diameter than array cables, due to the larger conductor cores required to transport greater volumes of power. The maximum design scenario for offshore export cables is shown in Table 3.25 and the maximum design scenario for the offshore cable route can be seen in (Table 3.26).

Table 3.25: Maximum design scenario: offshore export cables.

Parameter	Maximum design scenario
HVAC – number of circuits	6
HVAC – voltage (kV)	400
HVDC – number of circuits	4 (plus one HVAC circuit) [a]
HVDC – voltage (kV)	600
Cable diameter (mm)	320

a Assuming a maximum of four HVDC circuits plus one HVAC circuit which may be required to supply power from the onshore HVDC converter/HVAC substation to the offshore wind farm in some HVDC system designs..

Table 3.26: Maximum design scenario: offshore export cable route

Parameter	Maximum design scenario
Length of export cable corridor (km)	145
Export cable corridor width (km)	1.5
Length of export cable route – Including export cable within the array area (km)	173
Total length of export cables (km)	1,038

3.4.7.4 The export cable installation methodology as well as the burial depth and any requirement for protection measures will be defined by a detailed Cable Burial Risk Assessment (CBRA). Typically the cable will be buried at a depth of 1–2 m. The CBRA will inform cable burial depth which will dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent. It is likely the installation techniques will consist of one or a combination of trenching, dredging, jetting, ploughing, vertical injection, MFE and rock cutting. As with the array cables, the export cables will need to be made secure where the route crosses obstacles such as exposed bedrock, pre-existing cables or pipelines that mean the cable cannot be buried. This is typically achieved through some form of armouring (rock, mattress or proprietary separation layer) to maintain the integrity of the cable. Up to 10% of the total export cable length may require protection due to ground conditions (this excludes cable protection due to cable crossings). The methodology and parameters would be as described for array cables (see section 3.4.3). Up to 37 crossings per export cable may need to be undertaken with associated cable protection.

3.4.7.5 The maximum design scenario for offshore export cable installation can be seen in Table 3.27.

Table 3.27: Maximum design scenario: offshore export cable installation.

Parameter	Maximum design scenario
Installation methodology	Trenching, dredging, jetting, ploughing, mass flow excavation, vertical injection, rock cutting
Seabed disturbance (m^2)	14,460,000
Rock protection area (m^2)	726,600
Rock protection volume (m^3)	1,038,000
Burial spoil: jetting (m^3)	2,293,980
Burial spoil: ploughing/mass flow excavation (m^3)	6,228,000
Sand wave clearance volume in export cable route corridor (m^3)	182,056 m^3
Sand wave clearance volume in array area (for export cable) (m^3)	22,750
Duration (months)	36

3.4.7.6 The Hornsea Three offshore cable corridor crosses a number of existing assets, primarily oil and gas pipelines that connect to production wells in the North Sea. The design and methodology of these crossings will be confirmed in agreements with the asset owners, however it is likely that a berm of rock will be placed over the existing asset for protection, known as a pre-lay berm, or separation layer. The export cable will then be laid across this, at an angle close to 90 degrees. The export cable will then be covered by a second post lay berm to ensure that the export cable remains protected and in place. The rock berms will be inspected at regular intervals and may need to be replenished with further rock placement dependent on their condition. This operational rock placement would not exceed 25% of the original rock volume.

3.4.7.7 The final cable routing will, where feasible, aim to avoid existing sand waves and boulders along the offshore cable corridor, however there may be the need to clear sand waves and boulders, particularly in areas with extensive sandwaves and boulder fields, in order to provide a flat surface stable enough to allow the installation tools to install the cable to the required depth. The maximum design scenario for sandwave clearance for the export cable route is shown in Table 3.28.

Table 3.28: Export cable route sand-wave clearance.

Parameter	Maximum design scenario
Length of route affected by sandwaves (km)	34
Sand-wave clearance: Contingency (%)	50
Sand-wave clearance: Export Cable Route Total (m³)	182,056
Sand-wave clearance: Export Cable Within Array Area Total (m³)	22,750
Sand-wave clearance: Cromer Chalk bed MCZ (KPs 18 – 21) (m³)	0
Sand-wave clearance: North Norfolk Sandbanks and Saturn Reef (KPs 58 – 127) (m³)	121,200
Sand-wave clearance: Total in array area (export cables, array cables, interconnector cables) (m³)	168,325
Sand-wave clearance: Total in Markhams Triangle (export cables, array cables, interconnector cables) (m³)	33,595

3.4.8 Offshore interconnector cables

3.4.8.1 Hornsea Three may require power cables to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, or to connect to the offshore accommodation platforms in order to provide power for operation. The cables will have a similar design and installation process to the offshore export cables and array cables. The maximum design scenario is shown in Table 3.29.

3.4.9 Landfall

3.4.9.1 The offshore export cables will make landfall near Weybourne Hope in North Norfolk. The works at the landfall comprises the works required to bring the offshore export cables through the intertidal area to a location where they can be connected to the onshore export cables. The offshore cables are connected to the onshore cables at the Transition Joint Bays (TJBs). The works at the landfall would primarily be the same irrespective of if HVAC or HVDC transmission is selected.

3.4.9.2 TJBs are pits dug and lined with concrete, in which the jointing of the offshore and onshore export cables takes place. One TJB is required per export cable circuit. They are constructed to ensure that the jointing can take place in a clean, dry environment, and to protect the joints once completed. Once the joint is completed the TJBs are covered and the land above reinstated.

3.4.9.3 During landfall works, a construction compound is required on the onshore side of the beach. . This will house the TJB works as well as any Horizontal Directional Drilling (HDD) works, including supporting equipment and facilities.

Table 3.29: Maximum design scenario: offshore interconnector cables installation.

Parameter	Maximum design scenario
Installation methodology	Trenching, dredging, jetting, ploughing, mass flow excavation, vertical injection, rock cutting
Burial Depth	Typically 1-2m. Dependent on CBRA*
Seabed disturbance (excluding sandwave clearance) (m²)	2,250,000
Burial spoil: jetting (m³)	497,250
Burial spoil: ploughing/mass flow excavation (m³)	1,350,000
Rock protection area (m²)	157,500
Rock protection volume (m³)	225,000
Number of crossings (total)	2
Cable/pipe crossings: pre-lay rock berm area (m²)	1,200
Cable/pipe crossings: pre-lay rock berm volume (m³)	1,250
Cable/pipe crossings: post-lay rock berm area (m²)	5,600
Cable/pipe crossings: post-lay rock berm volume (m³)	4,000
Sand wave clearance volume (m³)	30,469
Total seabed disturbance (m²)	2,293,20

3.4.9.4 The techniques used to carry out the landfall works broadly fall in to two categories; open cut installation or trenchless techniques (i.e.HDD or thrust boring). It may be possible to carry out a HDD to beyond the intertidal area, and install the rest of the cable using an offshore installation spread. The technical feasibility of this approach will require confirmation via an intrusive geotechnical survey campaign. However, it may also be the case that the HDD is not possible (due to ground conditions, cable design, or other factors), in which case open cut techniques would be required to install the cable from offshore to the TJBs. It may also be the case that a HDD could be carried out to cross the shingle beach but would not reach the offshore area. In which case both methods would be required to carry out the landfall works.

3.4.9.5 Hornsea Three is currently conducting a number of geotechnical and geophysical surveys at the landfall site to confirm the technical feasibility of these approaches. The results of these surveys will be used to develop the methodology of the landfall works which will be presented within the Environmental Statement. The maximum design scenario for the landfall is shown in Table 3.30.

Table 3.30: Maximum design scenario for TJBs and landfall works.

Parameter	Maximum design scenario
Number of TJBs	8
TJB area (m^2)	250
TJB depth (m)	6
Landfall compound (m^2)	6,000
TJB working area (per TJB) (m^2)	1,600
Duration of trenching works (per cable) if open cut (weeks)	2
Duration of works for each HDD (months)	3
Duration of works (start – finish) (months)	24
Typical daily (non-HGV) vehicle movements	10
Typical daily HGV movements	5
Total (non-HGV) vehicle movements	1,200
Total HGV movements	600

3.4.10 Vessel activities

3.4.10.1 The total vessel numbers, vessel movements, and durations are collated in Table 3.31 below. Each vessel movement represents a return trip to and from the array site or export cable.

Table 3.31: Total values for vessel activities during construction phase.

Wind turbine installation information	Maximum design scenario
Installation vessels	4
Support vessels	24
Transport vessels	12
Installation vessels movements	342
Support vessels movements	2,052
Transport vessels movements	1,026
Helicopters movements	257

Wind turbine installation information	Maximum design scenario
Monopiles (WTG) construction (standard assumptions for other foundations if not stated)	
Installation vessels	4
Support vessels	16
Transport vessels (barges and tugs)	10 + 30
Feeder barge concept - installation vessels movements	342
Feeder barge concept - support vessels movements	1,368
Feeder Barge concept - transport barge movements	171
Feeder Barge concept - transport barge tug movements	513
Helicopters movements	684
Gravity Base (WTG) – construction (mutually exclusive with Monopile values above)	
Installation vessels	3
Support vessels	13
Dredging vessels	12
Tug vessels	4
Self-installing concept - support vessels movements	1,710
Self-installing concept - dredging vessels movements	1,368
Self-installing concept - tugs movements	1,368
Substation foundations construction	
Primary installation vessels	2
Support vessels	12
Transport vessels	4
Primary installation vessels movements	38
Support vessels movements	228
Transport vessels movements	38
Helicopter movements	532
Array cables installation	
Main laying Vessels	3
Main burial Vessels	3
Support vessels: crew boats or SOVs	4

Wind turbine installation information	Maximum design scenario
Support vessels: service vessel for pre-rigging of towers	2
Support vessels: diver vessels	2
Support vessels: vessels for PLGR	2
Support vessels: dredging vessels	2
Main laying Vessel movements	357
Main burial Vessel movements	357
Support vessels movements	2,142
Helicopter movements	684
Export cables installation	
Main laying vessels	3
Main jointing vessels	3
Main burial vessels	3
Support vessels: crew boats/service vessels	4
Support vessels: service vessel for pre-rigging of towers	2
Support vessels: diver vessels	2
Support vessels: vessels for PLGR	2
Support vessels: dredging vessels	3
Support vessels: survey vessels	2
Main laying vessels movements	180
Main jointing vessels movements	120
Main burial vessels movements	180
Support vessels movements	270
Helicopter movements	1,684

3.5 Onshore infrastructure

3.5.1 Onshore export cables

3.5.1.1 Onshore export cables will connect to the offshore export cables at the landfall point and transfer the power onwards to the onshore HVDC converter/HVAC substation (potentially via an onshore HVAC booster station in the case of HVAC). The onshore export cables will be buried for the entirety of the onshore export cable corridor. Overhead lines are not proposed for this project.

3.5.1.2 The onshore cable corridor search area used for this PEIR currently consists of an approximately 200 m wide corridor designed in accordance with a wide range of human, biological and physical constraints as well as technical and commercial considerations. The refined onshore cable corridor (80 m width) will be located within the onshore cable corridor search area and will be defined prior to the submission of the Environmental Statement. The onshore cable corridor search area gives sufficient flexibility to accommodate any changes that may be required as new data arises and considering feedback from consultees including individual landowners.

3.5.1.3 Up to six export cable circuits will be required containing a single conductor with each circuit consisting of three single cables. The cables themselves consist of copper or aluminium conductors wrapped with various materials for insulation, protection, and sealing. The maximum design scenario for onshore cables is shown in Table 3.32.

Table 3.32: Maximum design scenario: onshore export cables.

Parameter	Maximum design scenario
HVAC - number of cable circuits	6
HVAC - number of cables	18
HVDC – number of circuits [a]	4 (plus one HVAC circuit)
HVDC – number of cables [a]	11
Approximate onshore cable route length (km)	55
Voltage (kV)	600
Diameter of cable (mm) (HVDC)	220
Diameter of duct (mm) (HVDC)	330

a Assuming a maximum of four HVDC circuits plus one HVAC circuit which may be required to supply power from the onshore HVDC converter/HVAC substation HVDC converter substation to the offshore wind farm in some HVDC system designs.

3.5.1.4 The cables will be installed within an onshore cable corridor, with an expected width of 80 m (this includes both the permanent installation area and temporary working area).

3.5.1.5 The cables will be buried in multiple separate trenches (up to six trenches, each containing one circuit), however in some circumstances some trenches may be combined to aid installation. The export cables will be installed in sections of between 750 and 2,500 m at a time, with each section of cable delivered on a cable drum from which it is spooled out as it is installed. The installation of the onshore export cable is expected to take up to 30 months in total, however work is expected to progress along the route with a typical works duration of three months at any particular location. Construction may be carried out by multiple teams at more than one location along the cable route at the same time.

3.5.1.6 During construction of the cable trenches the topsoil and subsoil will be stripped and stored on site within the temporary working corridor of the onshore cable corridor as construction of each linear section of the route advances. The topsoil and subsoil will be stored in separate stockpiles as shown in Figure 3.25. Once the topsoil is stripped any required temporary roadways will also be installed along the route to allow trench excavation to take place.

3.5.1.7 The trenches will be excavated using a mechanical excavator, and the export cables will be installed into the open trench from a cable drum delivered to site via HGV. The cables are buried in a layer of stabilised backfill material that ensures a consistent structural and thermal environment for the cables. The remainder of the trench is then backfilled with the excavated material. Hard protective tiles, and marker tape are also installed in the cable trenches above the cables to ensure the cable is not damaged by any third party. Once the export cables are installed and the trenches backfilled, the stored topsoil will be replaced and the land reinstated back to its previous use.

3.5.1.8 Alternatively, ducts can be installed in the trenches in the same manner as above, and the cables can then be pulled through the ducts from the joint bays. This technique decouples the trenching from the cable installation and therefore can provide more flexibility for the installation process to optimise works and delivery of components.

3.5.1.9 The three cables of a HVAC circuit may either be installed in 'trefoil' formation, whereby two cables sit side by side, with a third sitting above the two cables, or in flat formation where the three cables will all sit side by side at the same level in the trench. The two cables required for HVDC circuits will sit side by side in the trench. The circuits must be spaced out in order to minimise the mutual heating effect of one circuit on another, this enables the cables to effectively carry the large power volumes required without overheating and damaging the cable.

3.5.1.10 Onshore cable joint bays (JBs) will be required along the onshore route, these are typically concrete lined pits, that provide a clean and dry environment for jointing the sections of cable together. As with the TJBs, these will likely be completely buried, with the land above reinstated. They will only require access in the event of a cable failure requiring replacement.

3.5.1.11 Link boxes (LBs) will also be required along the onshore route. These are smaller pits compared to joint bays which house connections between the cable shielding, joints for fibre optic cables and other auxiliary equipment. Land above the link boxes will also be reinstated, however, they may need manhole covers for access during the operational phase.

3.5.1.12 The onshore export cables will need to cross infrastructure and obstacles such as roads, railways and rivers. Hornsea Three will aim to undertake all major crossings, such as major roads, rivers and rail crossings using HDD. The detailed methodology for the crossings will be agreed with the relevant stakeholders such as third party asset owners, and other statutory stakeholders. Further detail on the crossing requirements along the route will be developed and presented alongside the Environmental Statement.

3.5.1.13 The exact depth and length of each HDD will be dependent on the nature of the obstruction being crossed as well as the ground conditions present at each site. Each HDD will require a compound at each side of the crossing to house the HDD rig and the various supporting equipment and components required. Further details on the equipment and processes to be used will be provided for the final ES.

3.5.1.14 It may be preferable for certain crossings to be carried out as an open cut crossing, rather than a HDD. These crossings could range from smaller drains, gas and power distribution infrastructure and small roads, to high pressure gas pipelines.

3.5.1.15 For some sensitive infrastructure such as high pressure gas pipelines the area around the pipeline must be carefully excavated by hand and the asset supported before installation of the cables below the pipelines can take place. This is preferred by some asset owners as visual confirmation of the integrity of the asset can be maintained throughout the works.

3.5.1.16 For smaller less sensitive infrastructure it can be quicker and less disruptive to make the crossings using open cut than undertaking the more onerous works required for HDD.

3.5.1.17 Construction compounds of various sizes will also be required along the onshore cable corridor, for laydown and storage of materials, plant and staff, as well as space for small temporary offices, welfare facilities, security and parking.

3.5.1.18 Construction compounds will also be required for crossings of other infrastructure to house operations such as drilling works. They will also be required around joint bay and link box construction.

3.5.1.19 A main construction compound will also be required. This would operate as a central base for the onshore construction works and would house the central offices, welfare facilities, and stores, as well as acting as a staging post and secure storage for equipment and component deliveries. The main construction compound does not need to be located on the route itself but on a suitable site in a central location in close proximity to the export cable route.

3.5.1.20 The construction compounds will be removed and sites restored to their original condition when construction has been completed. It may be necessary to retain some compounds during the commissioning stages of Hornsea Three. New temporary roads or access tracks for construction traffic are likely to be required at various points along the route, connecting compounds and construction sites to existing nearby roads. All compounds will be reinstated to their former condition following the construction phase, unless it is considered necessary to retain the use of a compound for a longer period post-construction.

3.5.2 Onshore HVAC booster station

3.5.2.1 The onshore HVAC booster station would have the same purpose as an offshore HVAC booster station(s), and contain similar equipment. An onshore HVAC booster station is required for the HVAC transmission only; it is not required for HVDC transmission.

Location

3.5.2.2 The site selection methodology for the onshore HVAC booster station is described in chapter 4: Site Selection Methodology and Consideration of Alternatives.

Design

3.5.2.3 The onshore HVAC booster station is primarily composed of High Voltage electrical reactors to correct the power factor of the transmitted electricity, as well as switchgear that connect the reactors into the export cable circuits. The onshore HVAC booster station would also contain auxiliary equipment for running and controlling the onshore HVAC booster station as well as structures to support and house the equipment. The equipment will either be housed within a single or multiple buildings, in an open yard or a combination of the above. There may also be some smaller buildings required to house components such as smaller equipment and control rooms. Indicative layouts for the onshore HVAC booster station are currently being developed and will be delivered included within the Environmental Statement. The maximum design scenario for the onshore HVAC booster station can be seen in Table 3.33.

3.5.2.4 The installation of the onshore HVAC booster station will require site preparation and enabling works as described for the onshore HVDC converter/HVAC substation. The list of civil engineering works required will be identified as the design of the onshore HVAC booster station develops and will be set out in the Environmental Statement.

3.5.2.5 A temporary working area will be installed adjacent to the onshore HVAC booster station which will be used to contain offices, stores, delivery and offloading areas.

Table 3.33: Design Envelope: onshore HVAC booster station.

Parameter	Maximum design scenario
Permanent area of site for all infrastructure (m^2)	25,000
Temporary area of site for construction works (m^2)	25,000
Single building [a]: length (m)	150
Single building [a]: width (m)	30
Number of buildings	6
Multiple buildings [a]: dimensions (length & width, if 6 buildings) (m)	25
Height of fire walls (m)	12.50
Building: height (m)	12.5
Maximum lightning protection height (m) (from ground level)	17.5

a The onshore HVAC booster station may comprise of a single building or multiple buildings on the same site.

3.5.3 Onshore HVDC converter/HVAC substation options

3.5.3.1 Depending on which transmission option is selected, the “onshore HVDC converter/HVAC substation” will either be an HVAC substation or a HVDC converter substation. For the remainder of this section, when “onshore HVDC converter/HVAC substation” is used, it is taken to mean the onshore HVDC converter substation or the HVAC substation unless otherwise stated.

3.5.3.2 The onshore HVDC converter/HVAC substation contains the electrical components for transforming the power supplied from the offshore wind farm to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid. If a HVDC system is used it will also house equipment to convert the power from HVDC to HVAC.

Location

3.5.3.3 Hornsea Three will connect to the National Grid at the Norwich Main 400 kV substation, located between Swardeston and Stoke Holy Cross in South Norfolk. The Hornsea Three onshore HVDC converter/HVAC substation will also be located in this vicinity. The site selection methodology for the onshore HVDC converter/HVAC substation is described in chapter 4: Site Selection Methodology and Consideration of Alternatives.

Design

3.5.3.4 The onshore HVDC converter/HVAC substation will consist of a range of equipment for delivery of the power to National Grid such as transformers, reactors, dynamic reactive power compensation plant (As STATCOM) filters and switchgear. It will also include a range of auxiliary and supporting equipment for the running and control of the substation. The main equipment will either be housed within a single or multiple buildings, in an open yard or a combination of the above. If multiple buildings are used the length and width of these buildings would be reduced proportionally to the number of buildings, e.g. if two buildings were used they would each cover half of the area required for the single larger building. There may also be some smaller buildings required to house components such as smaller equipment and control rooms. Indicative layouts for the onshore HVDC converter/HVAC substation are currently being developed and will be delivered within the Environmental Statement. The Maximum design scenario for the onshore HVDC converter/HVAC substation for both HVAC and HVDC options can be seen in Table 3.34 below.

Table 3.34: Maximum design scenario for onshore HVDC converter/ HVAC substation.

Parameter	Maximum design scenario
Permanent area of site for all infrastructure (m^2)	128,000
Temporary works area (m^2)	100,000
Main building - lightning protection height (m)	30
Height of fire walls (m)	20
HVAC Scenario	
HVAC – maximum number of main buildings	3
HVAC – length of main building (m)	150
HVAC – width of main building (m)	30
HVAC – height of main building (m)	25
HVDC Scenario	
HVDC – maximum number of main buildings	2
HVDC – width of main building (m)	75
HVDC – length of main building (m)	150
HVDC – height of main building(m)	25

Installation

3.5.3.5 The construction works for the onshore HVDC converter/HVAC substation are similar if using either the HVAC or HVDC solutions.

<u>Site preparation, enabling works and civils works.</u>

3.5.3.6 A compound will be set up that includes the permanent area required for the onshore HVDC converter/HVAC substation as well as a temporary working area required for storing and moving equipment and materials during the construction process. The topsoil of the site will be stripped and the site will be levelled as required. Civil works such as the laying of foundations and drainage, as well as the construction of buildings and supporting structures and systems will then be undertaken as required until the site is ready for the delivery of the electrical components.

<u>Electrical component installation and reinstatement</u>

3.5.3.7 The electrical equipment will then be installed and tested in readiness for the connection of the offshore wind farm, and the National Grid substation. Once the construction of the substation is complete the site will be secured and the supporting infrastructure finalised in readiness for the operations phase. The temporary area will be reinstated once construction is complete. The construction works at the onshore HVDC converter/HVAC substation may take up to 36 months. The temporary site may include a temporary viewing platform to enable visitors and staff to safely oversee the construction without entering the construction area itself. onshore HVDC converter/HVAC substation maximum design scenario.

3.5.4 Grid connection export cable

3.5.4.1 A further section of buried onshore export cabling is required to connect the Hornsea Three onshore HVDC converter/HVAC substation with the National Grid substation. This section of cabling will be similar in design to the onshore export cabling, but must be HVAC at 400 kV, and will have a maximum of four circuits, with a total of 12 export cables.

3.6 Construction phasing

3.6.1.1 A high-level indicative construction programme is presented in Figure 3.1 below. The programme illustrates the estimated duration of the major installation elements, and how they may relate to one another if built out in a single construction campaign (i.e. one phase). It covers installation of the major components and does not include elements such as preliminary site preparation, and commissioning of the wind farm post-construction. Onshore construction is currently planned to commence in 2021.

3.6.1.2 Hornsea Three may also be constructed in two or three phases, including the potential for an overlap or a gap between the completion of construction of one phase and the start of construction of another. However, if the construction of any phases are overlapping, the construction durations and total values for individual parameters will never exceed those stated for a single phase. For example, no more than four monopile installation vessels would be in use at any time, and no more than two monopiles would be piled simultaneously.

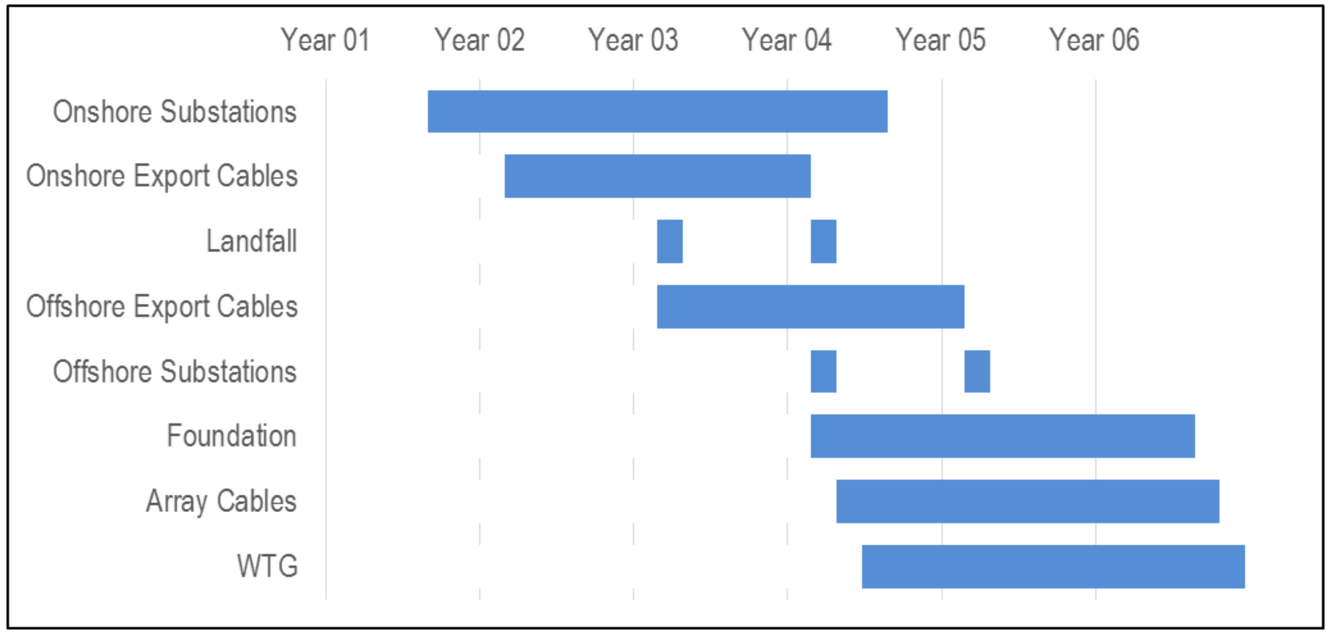

Figure 3.1: Indicative construction programme if the project is built out in a single phase.

3.6.1.3 It is possible that some activities may be carried out during an earlier phase for the benefit of a later one. However, any works completed for a later phase(s) would be left in a safe state, as agreed with the relevant authorities, to await the appropriate phase for completion.

3.7 Operation and maintenance and decommissioning

3.7.1.1 The indicative project programme outlined in Figure 3.1 above shows that the operation and maintenance phase will not commence until 2025, based on an onshore construction start date of 2021, with the decommissioning phase following the cessation of Hornsea Three. At this stage the exact activities undertaken during these phases are not known, however they will be further explored as part of the EIA and reported in the final Environmental Statement.

3.7.1.2 The overall operation and maintenance strategy will be finalised once the operation and maintenance onshore base location and technical specification of Hornsea Three are known, including turbine type, electrical export option and final project layout. The operation and maintenance strategy could include either an onshore operation and maintenance base, or an offshore operation and maintenance base (offshore accommodation platforms), or both. The general operation and maintenance strategy will rely primarily on crew vessels, offshore accommodation, supply vessels, and helicopters for the operation and maintenance services that will be performed at the wind farm.

3.7.1.3 Maintenance activities can be categorised into two levels: preventive and corrective maintenance. Preventive maintenance is according to scheduled services whereas corrective maintenance covers unexpected repairs, component replacements, retrofit campaigns and breakdowns. The onshore the operation and maintenance requirements will be largely corrective, accompanied by infrequent on-site inspections of the onshore transmission infrastructure. However, the onshore infrastructure will be consistently monitored remotely, and there may be operation and maintenance staff visiting the onshore HVDC converter/HVAC substation and onshore HVAC booster station to undertake works on a regular basis. At the end of the operational lifetime of the offshore wind farm, it is anticipated that all structures above the seabed or ground level will be completely removed. The decommissioning sequence will take approximately three years and will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. TCE AfL for Hornsea Three requires that the project is decommissioned at the end of its lifetime. The decommissioning plan and programme will be updated during Hornsea Three's lifespan to take account of changing best practice and new technologies.

4. Screening Exercise for Hornsea Three

4.1 Screening criteria

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

4.1.1.2 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.

4.1.1.3 The criteria used in screening for European sites takes account of the location of the sites relative to Hornsea Three, the zone of influence (ZoI) of potential impacts associated with Hornsea Three and the ecology and distribution of qualifying features. These criteria are described in Table 4.1.

4.1.1.4 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 4.1: 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[4] 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.

4.2 Potential impacts

4.2.1.1 The potential impacts arising from the construction, operation and maintenance and decommissioning of Hornsea Three are summarised in Table 4.2 and Table 4.3.

4.2.1.2 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.

[4] ZoI is defined for relevant features in Section 4.4

Table 4.2: 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 high 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	Long-term habitat loss	There is the potential for 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 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		

Table 4.3: 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	

4.3 Sites considered during HRA Screening

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

4.3.2 Sites designated for Annex I habitats (subsea and coastal)

4.3.2.1 It was assumed there is a LSE on any site which includes Annex I 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.

4.3.2.2 In addition to direct effects, for sites designated for 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.

4.3.2.3 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[5] (approximately 12 km) from the Hornsea Three offshore cable corridor search area has also been included to capture the zone of influence 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.

Table 4.4: European sites designated for Annex I habitat features (subsea and coastal) 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 SCI	• 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

4.3.3 Sites designated for Annex II diadromous migratory fish

4.3.3.1 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.

4.3.3.2 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*.

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

4.3.3.3 It should be noted, however, that there are no sites designated for Annex II fish species which overlapwith 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.

4.3.3.4 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.

4.3.3.5 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.

4.3.3.6 Following the screening criteria above, the European sites designated for Annex II diadromous fish species listed in Table 4.5 were identified for assessment of LSE.

Table 4.5: 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

4.3.3.7 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.

4.3.3.8 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.

4.3.4 Sites designated for Annex II marine mammals

4.3.4.1 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.

4.3.4.2 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.

4.3.4.3 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, 2016) were identified for assessment.

4.3.4.4 The regional study area is represented largely by SCANS Block U (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 4.6 below.

Table 4.6: 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 proposed Special Area of Conservation (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

4.3.5 Sites designated for Ornithological features

4.3.5.1 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.

4.3.5.2 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.

4.3.5.3 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).

4.3.5.4 Key amongst these is Flamborough Head and Bempton Cliffs SPA / Flamborough and Filey Coast 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.

4.3.5.5 European sites designated for birds, and their features, that could not be discounted during HRA screening are listed in Table 4.7.

4.3.6 Sites designated for Annex I habitats - onshore

4.3.6.1 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.

4.3.6.2 European sites designated for Annex I habitats identified following the criteria above, are listed in Table 4.8.

Table 4.7: European sites designated for ornithological features for which LSE has been identified or could not be discounted during HRA screening.

European site	Features
Greater Wash pSPA	• Red-throated diver • Common scoter
Flamborough and Filey Coast pSPA Flamborough Head and Bempton Cliffs SPA[6]	• 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 seasons) • Guillemot (non-breeding season) • Razorbill (non-breeding season)
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

[6] 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.

Table 4.8: 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
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.
The Wash and North Norfolk Coast SAC	• Atlantic salt meadows (Glauco-Puccinellietalia maritimae) • Coastal lagoons* • Large shallow inlets and bays • Mediterranean and thermo-Atlantic halophilous scrubs (Sarcocornetea fruticosi). (Mediterranean saltmarsh scrub) • Mudflats and sandflats not covered by seawater at low tide. (Intertidal mudflats and sandflats) • Reefs • Salicornia and other annuals colonising mud and sand (Glasswort and other annuals colonising mud and sand) • Sandbanks which are slightly covered by sea water all the time (Subtidal sandbanks)

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

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

4.3.7.1 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.

4.3.7.2 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.

4.3.7.3 European sites designated for Annex II species taken forward for determination of LSE, following the criteria set out above, are listed in Table 4.9.

Table 4.9: 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

4.4 Likely Significant Effects

4.4.1.1 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 01: HRA Screening Report. This presents the sites, features and potential impacts for which LSEs could not be excluded at the screening stage.

4.4.1.2 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 Draft Report to Inform Appropriate Assessment and is detailed in Table 4.10 and Table 4.11.

4.4.2 Benthic ecology

4.4.2.1 Four Natura 2000 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 (Annex I sandbanks and reefs);
- Haisborough, Hammond and Winterton SCI (Annex I sandbanks and reefs);
- North Norfolk Sandbanks and Saturn Reef SCI (Annex I sandbanks and reefs); and
- Klaverbank SCI (Annex I reefs).

4.4.2.2 Of these four sites only one (North Norfolk Sandbanks and Saturn Reef SCI) overlaps with Hornsea Three cable corridor. The other three sites listed above overlap with the marine processes buffer (Figure 6.1), however; there are no designated features which overlap (Figure 6.3) and are therefore only likely to be affected by increased suspended sediments (PEIR, 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), even in the Wash and North Norfolk coast SAC, would be expected to be particularly sensitive to increases in SSC or sediment deposition.

4.4.2.3 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 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.

4.4.2.4 For the above reasons the only Natura 2000 site considered in the PEIR is the North Norfolk Sandbanks and Saturn Reef SCI site. This approach is mirrored here in the Draft Report to Inform Appropriate Assessment which therefore also includes no transboundary assessment.

4.4.2.5 Discussions within the EWG led to the decision to include the assessment of non-native species as a an impact to the benthic ecology, within the assessment of colonisation of hard substrate within this Draft Report to Inform Appropriate Assessment, although this had not previously been included in the screening stage.

4.4.3 Marine mammals

4.4.3.1 Following consultation on the HRA Screening report is it was agreed with the marine mammal expert working group (EWG) (see Annex 2: draft 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.

4.4.3.2 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 Annex 2: draft Evidence Plan) that this impact will be considered 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 (PEIR, Volume 2 Chapter 1 and 3) .

4.4.4 Offshore ornithology

4.4.4.1 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.

4.4.4.2 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 herring gull feature of the Flamborough and Filey Coast pSPA; and
- Breeding fulmar non-listed assemblage feature of the Farne Islands pSPA and Coquet Island pSPA.

Lesser black-backed gull, Alde-Ore Estuary SPA

4.4.4.3 The Alde-Ore Estuary SPA is the only SPA (or pSPA) for which lesser black-backed gull is cited as a breeding feature and with potential connectivity to Hornsea Three i.e. within the mean-maximum foraging range being located approximately 90 km away(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 to take advantage of new foraging opportunities created by human activity e.g. construction activities that may make prey more available to them. 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.

4.4.4.4 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

4.4.4.5 Natural England in their responses to the screening exercise (Annex 01: 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.

4.4.4.6 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). One of the reasons the Greater Wash pSPA has been proposed is to protect the foraging waters of terns associated with the North Norfolk Coast SPA. Consequently if no predicted LSE is predicted for foraging terns within the Greater Wash pSPA, there is no prediction of an LSE on those species within the North Norfolk Coast SPA (no other pathway for an effect on these features at that site having been identified).

4.4.4.7 It was subsequently agreed in EWG meetings for offshore ornithology that both the Greater Wash pSPA and North Norfolk Coast SPA can be screened out of assessment for tern species and these are not considered further in this assessment (Annex 2, draft Evidence Plan).

Herring gull, Flamborough and Filey Coast pSPA

4.4.4.8 The HRA Screening Report identified a potential LSE in relation to collision risk impacts on the herring gull feature of the Flamborough and Filey Coast pSPA in the non-breeding season. An LSE was identified as site-specific data to inform the conclusions of the HRA screening report was unavailable at that time.

4.4.4.9 Site specific survey data (PEIR Volume 2, Chapter 5, Annex 5.1), now available has indicated insignificant numbers of herring gull present at Hornsea Three, and therefore herring gull collision risk effects have been screened out and this feature of the Flamborough and Filey Coast pSPA is not considered further in this assessment.

Fulmar, Farne Islands pSPA and Coquet Island pSPA

4.4.4.10 Natural England noted that sites at which fulmar was a non-listed assemblage feature (Farne Islands pSPA and Coquet Island pSPA) had not been considered in the HRA Screening Report. The potential for LSEs on fulmar was considered for the population at the Flamborough and Filey Coast pSPA which is located closer to Hornsea Three and the Forth Islands SPA with fulmar listed as an assemblage feature at both of these sites. The screening report concluded that there would be no LSEs on the fulmar feature at either of these SPAs in relation to all impacts associated with the construction, operation and decommissioning of Hornsea Three.

4.4.4.11 This rationale conclusion also applies to the more distant Farne Islands pSPA and Coquet Island pSPA and, therefore, the fulmar features of these sites are not considered further in this assessment.

4.4.5 Onshore ecology

4.4.5.1 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 appropriate assessment.

4.4.5.2 In addition to accidental pollution events, invasive non-native species are also included in the Draft Report to Inform Appropriate Assessment.

Table 4.10: 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 SCI	• 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 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 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 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 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 Increased vessel traffic and collision risk Accidental pollution events
			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 Increased vessel traffic and collision risk Accidental pollution events
			Operation and maintenance	Increased vessel traffic and collision risk Accidental pollution events

Receptor	Site	Feature	Project phase	Effect
Offshore Ornithology	Greater Wash pSPA	• Red-throated diver • Common scoter	Construction/decommissioning	Disturbance
			Operation and maintenance	Displacement
	Flamborough and Filey Coast pSPA Flamborough Head and Bempton Cliffs SPA	• Gannet	Operation and maintenance	Collision risk Displacement
		• Kittiwake	Operation and maintenance	Collision risk
		• Puffin	Construction/decommissioning	Disturbance
			Operation and maintenance	Displacement
		• Guillemot (non-breeding season)	Construction/decommissioning	Disturbance
			Operation and maintenance	Displacement
		• Razorbill (non-breeding season)	Construction/ decommissioning	Disturbance
			Operation and maintenance	Displacement

Table 4.11: European sites and features for which LSEs have been identified (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		Habitat fragmentation
			All qualifying features	Operation and maintenance	Temporary disturbance/damage Accidental pollution events

	Site	Feature		Project phase	Effect
	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
					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

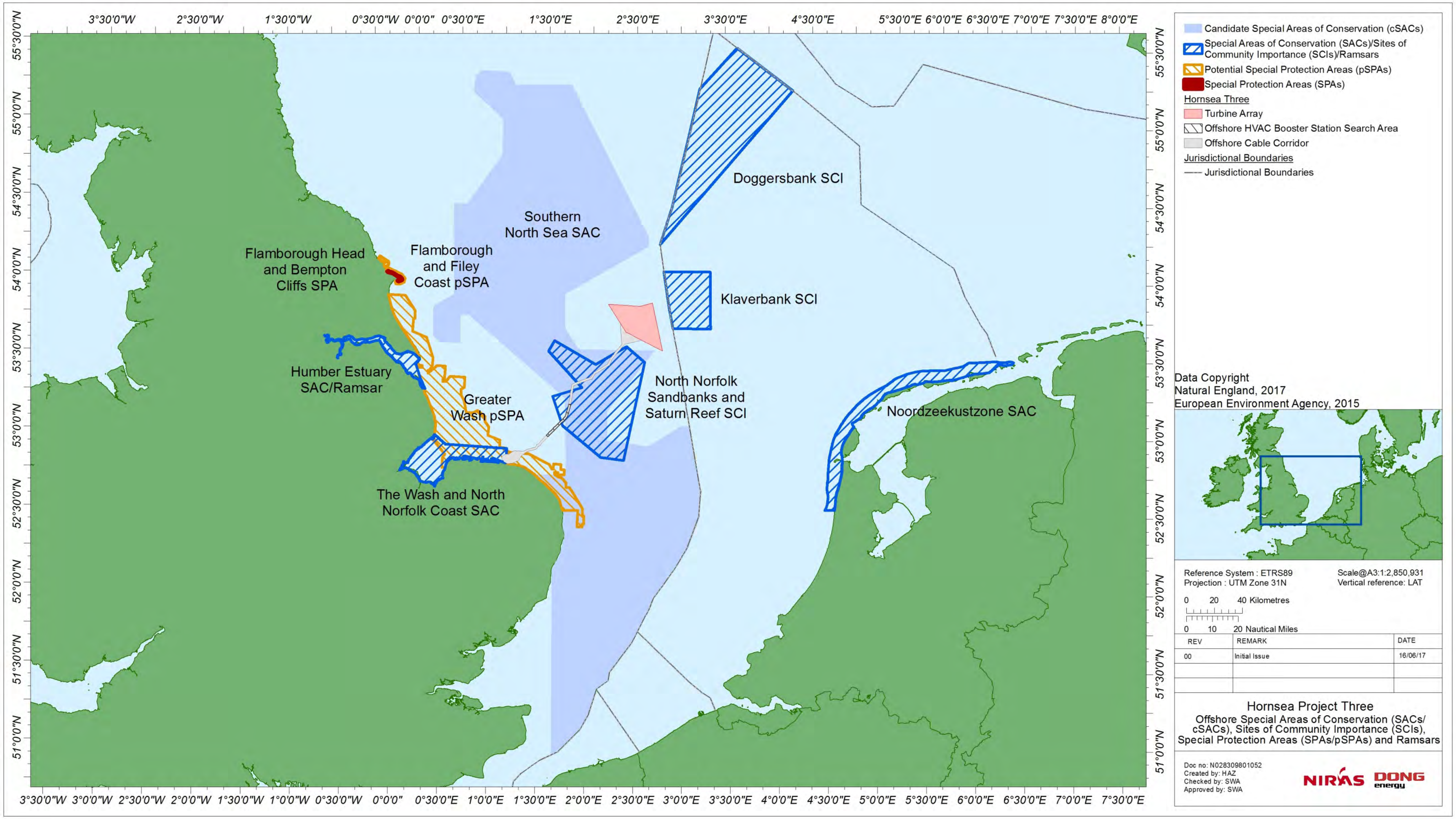

Figure 4.1: European sites with qualifying features for which LSEs have been identified / cannot be discounted (offshore).

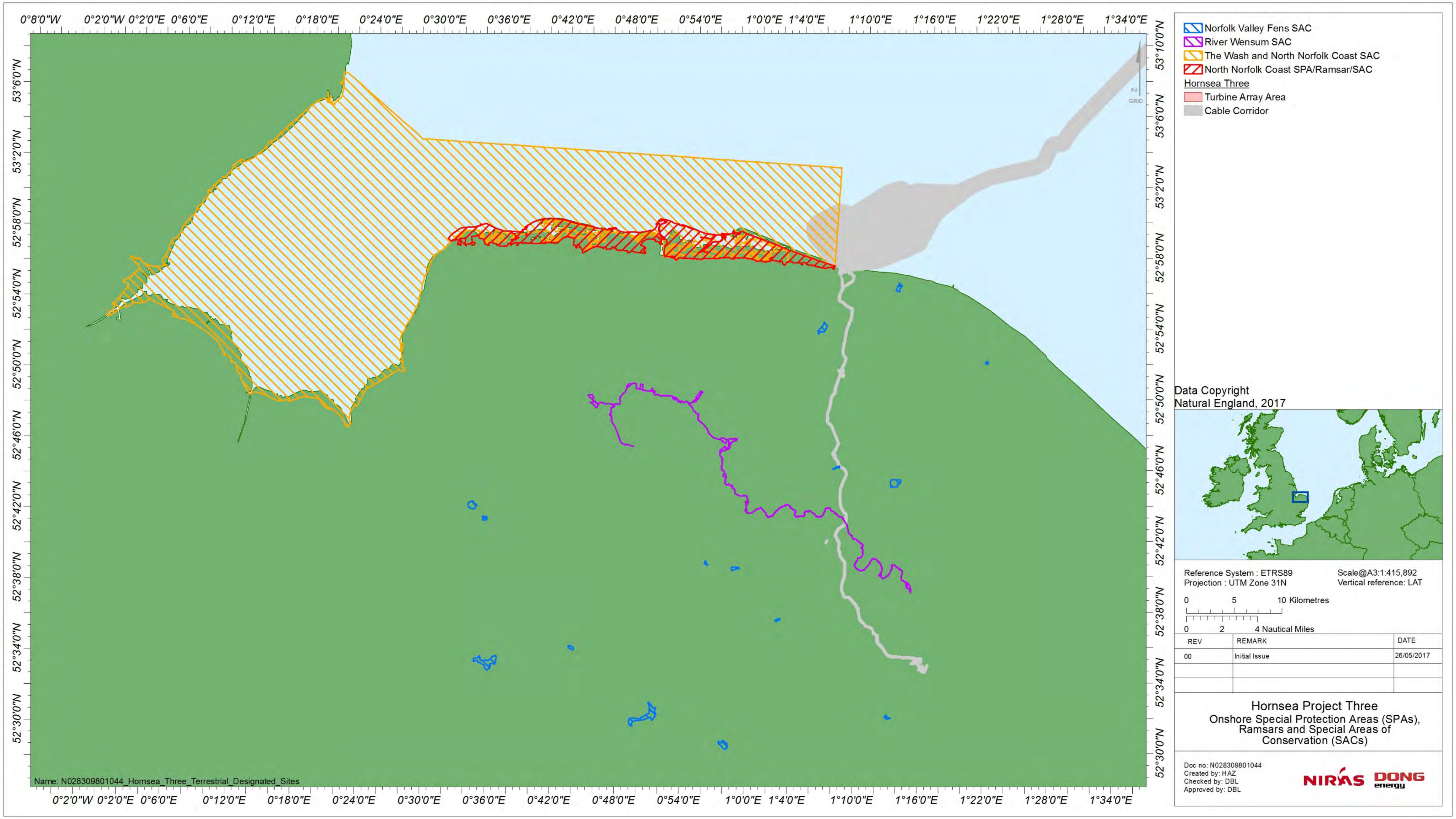

Figure 4.2: European sites with qualifying features for which LSEs have been identified (onshore).

5. Information to Inform the Appropriate Assessment

5.1 Introduction

5.1.1.1 As described in Section 4 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.

5.1.1.2 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 migratory fish, Annex II marine mammals, offshore bird features and terrestrial ecology.

5.2 Maximum design scenarios

5.2.1.1 The maximum design scenarios identified in Table 5.1 to Table 5.4 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 PEIR, 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 5.1: Maximum design scenario considered for the assessment of potential impacts on benthic ecology (table adapted to only show detail pertinent to the Draft Report to Inform Appropriate Assessment).

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.	*Offshore cable corridor - Subtidal* 14,460,000 m^2 from burial of up to 1,038 km of export cable (up to six trenches of 173 km length) by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by mobile sediment clearance and cable protection installation; up to 10 m width of seabed or 30 m for the 34 km of sandwaves along the offshore cable corridor). Up to a total of 364,112 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 182,056 m^3, placed on the seabed within the Hornsea Three offshore cable corridor. 351,600 m^2 from cable barge anchor placement associated with cable laying for all subtidal export cables 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 6 export cables (20,000 m x 7 x 100 m^2 x 6 / 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 6 export cables ((173,000 m – 20,000) x 1 x 100 m^2 x 6 / 500 m = 183,600 m^2). Construction phase lasting up to 11 years over two phases, with a gap of up to 6 years between the same activity between phases.	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, 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 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 volume 5, annex 1.1). Temporary loss of benthic habitat is assumed beneath this within the Hornsea Three array. 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 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.
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.	*Drilling operations for foundation installation: Greatest sediment disturbance from a single foundation location* Total sediment volume of 581,611 m^3 (113,104 + 253,338 + 193,962 + 21,207), comprising: 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). 253,338 m^3 total spoil volume from largest offshore High Voltage Alternating Current (HVAC) collector substation piled jacket foundations (up to 12 foundations), 24 piles per foundation (six legs, four piles per leg), 4 m diameter, drilling to 70m 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). 193,962 m^3 total spoil volume from the largest offshore High Voltage Direct Current (HVDC) converter substation piled jacket foundations (up to four foundations), 72 piles per foundation (18 legs, four piles per leg), 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 (4 x 48,490 m^3 = 193,962 m^3). 21,207 m^3 total spoil volume from the largest offshore accommodation platform monopile foundations (up to 3 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 (3 x 7,069 m^3 = 21,207 m^3). Up to two foundations may be simultaneously drilled, minimum spacing 1,000 m. Disposal of drill arisings at water surface. Construction phase lasting up to 11 years over two phases, with a gap of up to 6 years between the same activity between phases.	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 HVAC collector substations and up to four offshore HVDC converter substations) results in the largest number of offshore substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option.

Potential impact	Maximum design scenario	Justification
	Dredging for seabed preparation for foundation installation: Greatest sediment disturbance from a single foundation location Total sediment volume of 1,827,287 m^3 (935,200 + 735,000 + 139,552 + 17,535), comprising: 935,000 m^3 total spoil volume from largest turbine gravity base foundation (up to 160 gravity base foundations), 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 HVAC collector substation gravity base foundation (up to 12 gravity base foundations), 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 HVDC converter substation gravity base foundation (up to four gravity base foundations), 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 (4 x 34,888 m^3 = 139,552 m^3). 17,535 m^3 total spoil volume from largest offshore accommodation platform gravity base foundation (up to three gravity base foundations), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m^3 (3 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 TBC dredgers to be working simultaneously, minimum spacing 1,000 m. Construction phase lasting up to 11 years over two phases, with a gap of up to 6 years between the same activity between phases.	Dredging as part of seabed preparation for individual gravity base 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 HVAC collector substations and up to four offshore HVDC converter substations) results in the largest number of offshore substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option. Note: this assessment considers effects on benthic ecology from a passive plume (i.e. sediments transported via tidal currents) during dredging and disposal operations for foundation installation. Placements of coarse dredged materials during dredge disposal are considered in temporary habitat loss.
	Cable Installation Total sediment volume of 13,026,381 m^3 5,100,000 + 168,325 + 1,350,000 + 6,226,000 + 182,056), comprising: Array cables • Installation method: mass flow excavator; • Total length 850 km; • 5,100,000 m^3 total spoil volume from installation of up to 850 km cables in a V-shape trench of width = 6 m and depth =2 m (850 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 5,100,000 m^3); and • 168,325 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). Substation interconnector cables • Installation method: mass flow excavator; • 15 in-project 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 173 km in length (1,038 km in total);	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
	• Installation method: mass flow excavator; • 6,226,000 m³ total spoil volume from installation of up to 225 km cables in a V-shape trench of width = 6 m and depth =2 m (6 x 173 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 6,226,000 m³); and • 182,056 m³ 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 11 years over two phases, with a gap of up to 6 years between the same activity between phases.	
Seabed disturbances within the offshore cable corridor leading to the release of sediment contaminants and resulting in potential effects on benthic ecology.	Seabed disturbance arising from installation of foundations and cables as described above for temporary increases in suspended sediments (Cable Installation - Export cables only).	This scenario represents the maximum design scenario for offshore cable corridor installation and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities. Potential impacts of release of contaminants were scoped out for the Hornsea Three Array.
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 11,566 vessel movements during the construction phase: • 4,446 vessel movements over construction period based on gravity base foundations (self-installing concept); • Up to 3,420 vessel movements over construction period for WTG installation; • Up to 304 vessel movements over construction period for substations; • Up to 2,856 vessel movements over construction period for array cables; and • Up to 540 vessel movements over construction period for export cable. Water-based drilling muds associated with drilling to install foundations, should this be required. 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.	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.	*Offshore Cable Corridor - Cable Protection* Up to a total of 726,600 m² based on the installation of cable protection for 10% of the up to 1,038 km of export cable. Assumes up to six cables, and up to 7 m width of cable protection per cable; and Up to a total of 621,600 m² for cable/pipeline crossings, with up to 37 crossings, assuming up to six cables, with each crossing having a long term loss of seabed (i.e. through placement of rock berms across a length of up to 400 m) of up to 2,800 m². rotection 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.	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. Maximum design scenario is associated with the installation of gravity based foundations for all turbines, box GBFs for HVAC collector substations, suction caisson jacket foundations for offshore accommodation platforms and pontoon GBFs for four offshore HVDC substations as these foundations have the largest total surface area in contact with the seabed and therefore result in the greatest long term habitat loss. The maximum design scenario also assumes scour protection is required for all foundations. 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 substation interconnector power cables. The maximum design scenario assumes that 10% of the subtidal export cables will require cable protection (i.e. rock placement).

Potential impact	Maximum design scenario	Justification
Colonisation of foundations/cable protection/scour protection may affect benthic ecology and biodiversity.	*Offshore Cable Corridor - Cable Protection* Up to a total of 898,581 m^2 from the installation of cable protection for 10% of the up to 1,038 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 m^2. Up to a total of 768,729 m^2 from installation of cable protection for up to 37 cable/pipeline crossings along the offshore cable corridor. Each crossing will be of 400 m length each and 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.	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 array and subtidal export cables require secondary protection. It also assumes no rock placement will be used in the intertidal. For GBFs, this area includes the surfaces of the foundation shaft, cone and base from the seabed to MHWS (i.e. including intertidal habitat).
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. Increased risk of introduction or spread of INNS from up to 11,566 vessel movements during the construction phase (see Accidental release of pollutants impact assessment above for breakdown) and up to 2,832 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 gravity base foundations for turbines (up to 342 of 41 m diameter) and offshore accommodation platforms (up to three of 41 m diameter) and the largest dimensions of gravity base foundation for offshore HVAC collector substations (up to 12 of 75 m length scale) and offshore HVDC converter substations (up to four 75 m length scale) in the array area Largest number of offshore HVAC booster station gravity base foundations (up to four foundations, associated base dimensions 75 m) in the Hornsea Three offshore cable corridor. 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 as a whole, local scour footprint was greatest around an array of 160 x 15 m diameter monopile foundations. For the Hornsea Three array as a whole, the global scour footprint was greatest for an array of 342 x piled jacket foundations of 32 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 gravity base foundation foundations 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 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 volume 5, annex 1.1: Marine Processes Technical Annex. Each foundation type may produce different scour patterns therefore monopiles, gravity base foundations 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 of up to 2,218,500 m^2 comprising: A total of up to 87 jack-ups per year over the 25 year design life, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 87 x 25 x 6 x170). Preventive maintenance of subsea cables including routine inspections to ensure the cable is buried to an adequate depth and not exposed. The integrity of the cable and cable protection system (i.e., bending restrictors and bend stiffeners) will also be inspected. It is expected that on average the subsea cables will require up to two visits per year for the first three years before being reduced to yearly thereafter. Maintenance works to rebury/replace and carry out repair works on subtidal array, substation interconnector and export cables, should this be required.	These parameters are considered to represent the likely maximum design scenario for the requirement for jack-up barge operations for all WTGs and substations for the lifetime of the project. No substantive maintenance works on the export cables at the offshore cable corridor landfall site 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 the project 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 342 turbines, up to 12 offshore HVAC collector 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 2,832 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 25,234 round trips by helicopter per year over the 25 year design life. A typical 7 MW turbine is likely to contain approximately 1,300 l of grease, 20,000 l of hydraulic oil and 2,000 l of gear oil, 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel and 13,000 l of coolant. 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. 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.
Decommissioning phase		
Temporary loss of habitat due to operations to remove array cables, substation interconnector cables and export cables, and jack-up operations to remove foundations, resulting in potential effects on benthic ecology.	*Offshore cable corridor - Subtidal* 14,460,000 m^2 from removal of up to 1,038 km of export cable (up to six trenches of 173 km length) by trenching, jetting, mass flow excavator or vertical injection and similar tools currently under development augmented by mobile sediment clearance and cable protection installation (up to 10 m width of seabed or 30 m for the 34 km of sandwaves along the offshore cable corridor). Up to a total of 364,112 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 182,056 m^3, placed on the seabed within the Hornsea Three offshore cable corridor. 351,600 m^2 from cable barge anchor placement associated with cable laying for all subtidal export cables broken down as follows: • First 20 km of offshore cable corridor: Up to seven anchors (footprint of 100 m^2 each) repositioned every 500 m for up to 6 export cables (20,000 m x 7 x 100 m^2 x 6 / 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 6 export cables ((173,000 m – 20,000) x 1 x 100 m^2 x 6 / 500 m = 183,600 m^2). *Offshore cable corridor - Intertidal* 43,363 m^2 from works to remove 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) assuming habitat loss/disturbance within entire corridor width. Some limited habitat loss/disturbance may also occur within the intertidal temporary working areas either side of the intertidal cable corridor (228,551 m^2) due to activities such as vehicle movements, anchor placement and the purposeful grounding of vessel (e.g. barge) involved in decommissioning.	Maximum design scenario as per construction phase, excluding seabed preparation works, and assumes the removal of all foundations and all buried subtidal and intertidal cables. Piled foundations would be removed to approximately 2 m below the seabed. The necessity to remove cables will be reviewed at the time, after consideration of the environmental impact of the removal operation and safety of the cables left in situ (see volume 1, chapter 3: Project Description). Therefore, the maximum design scenario has assumed the removal of all cables, although this is likely to be over precautionary.

Potential impact	Maximum design scenario	Justification
Temporary increases in suspended sediment concentrations and deposition from removal of array cables, export cables and foundations resulting in potential effects on benthic ecology.	Increases of suspended sediment concentrations and sediment deposition associated with the removal of up to 361 foundations (i.e. up to 342 turbines, up to 12 offshore HVAC collector 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) and up to 2,113 km of array (including substation interconnector cables) and export cables.	Maximum design scenario as per construction phase and assumes the removal of all foundations and all subtidal and intertidal cables.
Permanent habitat loss due to presence of scour/cable protection left in situ post decommissioning, and potential effects on benthic ecology.	*Offshore cable corridor - Subtidal* Up to a total of 726,600 m^2 based on the installation of cable protection for 10% of the up to 1,038 km of export cable. Assumes up to six cables, and up to 7 m width of cable protection per cable; and Up to a total of 621,600 m^2 for cable/pipeline crossings, with up to 37 crossings along the offshore cable corridor, assuming up to six cables, with each crossing with long term loss of seabed (i.e. through placement of rock berms across a length of up to 400 m) of up to 2,800 m^2. 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.	Maximum design scenario for long term habitat loss as per operational phase but assuming that foundations will be removed but scour and cable protection will be left in situ.
Accidental release of pollutants (e.g. from accidental spillage/leakage) may affect benthic ecology.	Maximum design scenario is identical to that of the construction phase.	Maximum design scenario as per construction phase.

Table 5.2: 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 spatial: monopile foundations with concurrent piling Up to 361 monopiles (342 turbine foundations and 19 foundations for other infrastructure and platform foundations) • Piling of up to 342 monopile foundations of 7 m diameter; • Piling of up to 19 monopile foundations, 15 m diameter, for substations and platforms including: o Three offshore accommodation platforms; o Twelve offshore HVAC collector substations; and o Four offshore HVAC booster stations (on the Hornsea Three offshore cable route corridor). • 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; • Maximum four hours piling duration per monopile (including 30 minute soft start) within a 24 hour period; • Maximum total duration of actual piling is 1,444 hours (four x 361); • Piling within Hornsea Three array area could occur as single vessel scenario or two concurrent vessels (at opposite ends of the site) although maximum design spatial scenario is for concurrent piling. Concurrent piling will occur only within the Hornsea Three array area and not within the Hornsea Three offshore cable corridor; • 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 number of days (single vessel scenario) on which piling could occur is 433.2 days, which consists of: o Hornsea Three array area = 428.4 days (357 days piling for 342 turbines + three accommodation platforms + 12 offshore HVAC collector substations * 20% contingency); and o Hornsea Three offshore cable corridor = 4.8 days (four days piling for four offshore HVAC booster stations * 20% contingency). • Or minimum number of days (concurrent vessel scenario) on which piling could occur is 216.6 days, which consists of: o Hornsea Three array area = 214.2 days (178.5 days piling for 342 turbines + three accommodation platforms + 12 offshore HVAC collector substations * 20% contingency); and o Hornsea Three offshore cable corridor = 2.4 days (two days piling for four offshore HVAC booster stations * 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 six 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 area of effect from subsea noise at any one time during piling. The subsea noise Inspire 'lite' modelling showed that the greatest area of effect was for 5,000 kJ hammer and a 7 m diameter pile. The area of ensonification for a 15 m diameter pile was, in fact, smaller than for a 7 m diameter pile (due to the higher frequency components of the smaller pile leading to greater propagation; see section 5.1.1.2 in volume 4, annex 3.1: Subsea Noise Technical Report) and therefore the maximum design scenario presented here captures all pile diameters within the project description up to and including the largest 15 m diameter pile. The HVAC transmission option results in the maximum design scenario spatially due to the potential of monopile foundations for the offshore HVAC booster stations. Two vessels piling concurrently at maximum spacing would result in the largest area of impact at any one time. 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.

<table>
<tr><th>Potential impact</th><th>Maximum design scenario</th><th>Justification</th></tr>
<tr><td></td><td>
<u>Maximum design temporal: jacket foundations with single piling</u>
<u>Up to 2,016 pin piles (1,368 for turbine foundations and 648 for other infrastructure and platform foundations)</u>

Piling of up to 342 jacket foundations (four piles per foundation, each pin pile 4 m diameter), with up to 1,368 piles (342 x 4) in total;
Piling of up to 19 jacket foundations, up to 4 m diameter, for substations and platforms including:

Three offshore accommodation platforms (six legs with four piles per leg), with up to 72 piles (three x 24) in total;
Twelve offshore HVAC collector substations (six legs with four piles per leg), with up to 288 piles (12 x 24) in total; and
Four offshore HVDC converter substations (72 piles per foundation) with up to 288 piles (four x 72) in total.

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 8,064 hours of piling (four x 2,016);
Piling could occur as single vessel scenario or two concurrent vessels (at opposite ends of the site) although maximum design temporal scenario is for <u>single piling</u>;
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 <u>maximum</u> number of days (single piling scenario) on which piling could occur is 604.8 days (2,016 pin piles ((1,368 pin piles for turbines + 72 pin piles for accommodation platforms + 288 pin piles for offshore HVAC collector substations + 288 pin piles for offshore HVDC converter substations) / four a day) x 20% contingency) within the Hornsea Three array area.
Or <u>minimum</u> number of days (concurrent piling scenario) on which piling could occur is 302.4 days (2,016 pin piles ((1,368 pin piles for turbines + 72 pin piles for accommodation platforms + 288 pin piles for offshore HVAC collector substations + 288 pin piles for offshore HVDC converter substations) / eight a day) x 20% contingency) within the Hornsea Three array area.
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 six years between phases.

</td><td>
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).

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, although realistically there is potential to install up to eight piles in one 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.
</td></tr>
<tr><td>Increased vessel traffic during construction may result in an increase in disturbance to or collision risk with marine mammals.</td><td>
Total of 11,776 vessel movements throughout the Hornsea Three array area and offshore cable corridor during a two phase construction scenario over a total offshore construction period of 11 years, with a gap of up to six years between the same activity in each construction phase), comprising:

Up to 4,446 vessel movements over construction period based on gravity base foundations (self-installing concept);
Up to 3,420 vessel movements over construction period for turbine installation;
Up to 304 vessel movements over construction period for substations;
Up to 2,856 vessel movements over construction period for array cables; and
Up to 750 vessel movements over construction period for the export cable.

A range of vessels (engine sizes and speeds) will be used during the construction phase, specified within the project description (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.
</td><td>
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.
</td></tr>
</table>

Potential impact	Maximum design scenario	Justification
Increased suspended sediments arising from construction activities, such as cable and foundation installation, may reduce water clarity and impair the foraging ability of marine mammals.	<u>Drilling operations for foundation installation: greatest sediment disturbance from a single foundation location</u> Total sediment volume of 581,611 m³ (113,104 + 253,338 + 193,962 + 21,207), comprising: • 113,097 m³ (160 x 10% x 7,069 m³) of spoil as a result of the largest turbine monopile foundations (up to 160 monopiles with an associated diameter of up to 15 m drilled to a penetration depth of up to 40 m) and up to 10% of foundations drilled, with a spoil volume of up to 7,069 m³ per foundation (160 x 10% x 7,069 m³ = 113,104 m³; • 253,338 m³ (12 x 21,112 m³) of spoil as a result of up to 12 offshore HVAC collector substations with piled jacket foundations (up to 24 piles per foundation (six legs, four piles per leg), up to 4 m diameter per pile, drilled to a penetration depth of up to 70 m and a spoil volume of up to 21,112 m³ per foundation) and up to 100% of foundations may be drilled (12 x 21,112 m³ = 253,338 m³); • 193,962 m³ (four x 48,490 m³) of spoil as a result of up to four offshore HVDC converter substations with piled jacket foundations (up to 72 piles per foundation (18 legs, four piles per leg), up to 3.5 m diameter per pile, drilled to a penetration depth of up to 70 m and a spoil volume of up to 48,490 m³ per foundation) and up to 100% of foundations may be drilled (four x 48,490 m³ = 193,962 m³); • Up to 21,207 m³ (three x 7,069 m³) of spoil as a result of up to three offshore accommodation platforms with monopile foundations (up to three monopiles with an associated diameter of up to 15 m, drilled to a penetration depth of up to 40 m and a spoil volume of up to 7,069 m³ per foundation) and up to 100% of foundations may be drilled (three x 7,069 m³ = 21,207 m³); • Up to two foundations may be simultaneously drilled with a minimum spacing of 1,000 m; • Disposal of drill arisings at water surface; and • Construction phase lasting up to 11 years over two phases, with a gap of up to six years between the same activity between phases	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 suspended sediment concentrations (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 HVAC collector substations and up to four offshore HVDC converter substations) results in the largest number of offshore substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option.
	<u>Dredging for seabed preparation for foundation installation: greatest sediment disturbance from a single foundation location</u> Total sediment volume of 1,827,287 m³ (935,200 + 735,000 + 139,552 + 17,535), comprising • 935,000 m³ total spoil volume per foundation based on the largest turbine gravity base foundation (up to 160 gravity base foundations), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m, spoil volume per foundation 5,845 m³ (160 x 5,845 = 935,000 m³); • 735,000 m³ total spoil volume per foundation for the largest offshore HVAC collector substation gravity base foundation (up to 12 gravity base foundations), associated base dimensions 75 m, associated bed preparation area dimensions 175 m, average depth 2 m, spoil volume per foundation 61,250 m³ (12 x 61,250 m³ = 735,000 m³); • 139,552 m³ total spoil volume per foundation for the largest offshore HVDC converter substation gravity base foundation (up to four gravity base foundations), 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 m³ (four x 34,888 m³ = 139,552 m³); • 17,535 m³ total spoil volume per foundation for the largest offshore accommodation platform gravity base foundation (up to three gravity base foundations), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m, spoil volume per foundation 5,845 m³ (three x 5,845 m³ = 17,535 m³); • Disposal of material on the seabed within Hornsea Three; • Dredging carried out using a representative trailer suction hopper dredger (11,000 m³ hopper capacity with split bottom for spoil disposal). Up to TBC dredgers to be working simultaneously is to be confirmed, and a minimum spacing of 1,000 m.; and Construction phase lasting up to 11 years over two phases, with a gap of up to six years between the same activity between phases. .	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 HVAC collector substations and up to four offshore HVDC converter substations) results in the largest number of offshore substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option. Note: this assessment considers effects on benthic ecology from a passive plume (i.e. sediments transported via tidal currents) during dredging and disposal operations for foundation installation. Placements of coarse dredged materials during dredge disposal are considered in temporary habitat loss

Potential impact	Maximum design scenario	Justification
	Cable installation Total sediment volume of 13,026,381 m³ (5,100,000 + 168,325 + 1,350,000 + 6,226,000 + 182,056), comprising: Array cables • Installation method: mass flow excavator; • Total length 850 km; • 5,100,000 m³ total spoil volume from installation of up to 850 km cables in a V-shape trench of width = 6 m and depth =2 m (850 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 5,100,000 m³); and • 168,325 m³ 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). Substation interconnector cables • Installation method: mass flow excavator; • 15 in-project cables, total length 225 km; and • 1,350,000 m³ 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 m³). Export cables • Up to six cable trenches; each 173 km in length (1,038 km in total); • Installation method: mass flow excavator; • 6,226,000 m³ total spoil volume from installation of up to 225 km cables in a V-shape trench of width = 6 m and depth =2 m (six x 173 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 6,226,000 m³); and • 182,056 m³ 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). • Offshore construction phase lasting up to 11 years over two phases with a gap of up to six years between the same activity between phases..	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.
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 construction vessels (maximum of 11,566 round trips to ports over the construction period): • 4,446 vessel movements over the construction period based on gravity base foundations (self-installing concept); • Up to 3,420 vessel movements over construction period for WTG installation; • Up to 304 vessel movements over construction period for substations; • Up to 2,856 vessel movements over construction period for array cables; and • Up to 540 vessel movements over construction period for the export cable. 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.	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
Changes in the fish and shellfish community resulting from impacts during construction may lead to loss of prey resources for marine mammals.	Changes in the fish and shellfish community based on maximum design scenarios presented in chapter 3: Fish and Shellfish, for the following impacts: • Subsea noise from piling over a 2.5 year piling phase; • Total subtidal temporary habitat loss of 23,888,423 m^2 due to seabed preparation for gravity base foundations, sandwave clearance, and trenching for cable installation in up to three phases over an offshore construction window of up to 11 years; • Increased sediment deposition arising from installation of foundations for 342 turbines, dredging for seabed preparation and cable installation over a 11 year construction window; and • Potential for contamination arising from installation works and construction vessels could over a two phase construction scenario, with a gap of up to six years between activities.	This represents the maximum design scenarios for fish and shellfish receptors as described in chapter 3: Fish and Shellfish Ecology, and therefore the maximum design scenario for effects on marine mammal prey species.
Operation phase		
Noise and vibration arising from operational turbines may cause disturbance to marine mammals.	Subsea noise and vibration arising from the operation of up to 342 turbines over a project lifetime of 25 years.	The maximum design scenario is based on the maximum number of turbines over the maximum lifetime of the project rather than size of turbine since the potential effects are expected to be localised regardless of the power output (Madsen *et al*., 2006, Newdwell *et al*., 2007).
Increased vessel traffic during operation and maintenance may result in an increase in disturbance to marine mammals.	Total return vessel movements per year during operation = 2,832. Vessel activity throughout the Hornsea Three array area and offshore cable corridor comprising: • Jack up wind turbine visits: up to 82 visits per year over project lifetime; • Jack up platform visits: up to five visits per year over project lifetime; • Crew vessel visits: up to 2,433 per year over project lifetime; and • Supply vessel accommodation platform visits: up to 312 per year over project lifetime.	The maximum design scenario represents the maximum number of vessels and range of vessels likely to lead to disturbance.
Electromagnetic Fields (EMF) emitted by -array and export cables may affect marine mammal behaviour.	EMF resulting from a total of 2,113 km of cables: • Up to 850 km of array cable (maximum 170 kV); • Up to 225 km of interconnector cables (maximum 600 kV if HVDC or 400 kV if HVAC transmission); and • Up to 1,038 km (six x 173 km) of export cable (maximum 400 kV if HVAC transmission option and 600 kV if HVDC transmission option). The maximum design scenario is that array cables, export cables and interconnector cables will either be buried to a target minimum burial depth of 1 m or by cable protection subject to a cable burial risk assessment.	HVDC transmission represents the maximum design scenario for magnetic field strengths, though for induced electrical fields it is unclear whether HVAC or HVDC transmission represents the maximum design scenario. Both HVDC and HVAC transmission have therefore been assessed.

Potential impact	Maximum design scenario	Justification
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 342 turbines, up to 12 offshore HVAC collector 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 2,832 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 25,234 round trips by helicopter per year over the 25 year design life). A typical turbine is likely to contain approximately 1,300 l of grease, 20,000 l of hydraulic oil and 2,000 l of gear oil, 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel and 13,000 l of coolant. 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
Changes in the fish and shellfish community resulting from impacts during operation and maintenance may lead to loss of prey resources for marine mammals.	Changes in fish and shellfish community over the lifetime (25 years) of the project due to: • Long term loss of 6,392,484 m² of benthic habitat (from 342 turbines, anchors, mooring lines, drag anchor scour protection); • Underwater noise from operation of up to 342 turbines and maintenance vessel traffic; • Introduction of 5,046,797 m² hard substrates from foundations, scour protection and cable protection; • Maximum EMF as described above; • Reduced fishing pressure within the Hornsea Three array area; and • Accidental release of pollutants from WTGs, substations, accommodation platforms and vessel movements as described above.	This represents the maximum design scenarios for fish and shellfish receptors as described in chapter 3: Fish and Shellfish Ecology, and therefore the maximum design scenario for effects on marine mammal prey species.
Decommissioning phase		
Underwater noise arising from turbine and cable removal within the Hornsea Three array area and the Hornsea Three offshore cable corridor and associated vessels may cause disturbance to marine mammals.	Underwater noise associated with decommissioning: • Removal of 361 foundations: 342 turbines, three offshore accommodation platforms, 12 offshore HVAC collector substations and four offshore HVDC substations /offshore HVAC booster stations; • Removal of 2,113 km of cables (1,038 km of subtidal export cable (i.e. 6 x 173 km cables), 850 km of array cable, and 225 km interconnector cable); and • Up to 11,566 vessel round trips during the decommissioning phase.	Maximum design scenario assumes largest number of foundations, maximum cable length and greatest number of return trips to port during the decommissioning phase. Total number of vessel movements is assumed to be the same as during the construction phase.
Increased vessel traffic during decommissioning activities may result in an increased collision risk to marine mammals.	Increased vessel movements during decommissioning of up to 361 foundations (i.e. up to 342 turbines, up to 12 offshore HVAC collector substations, up to four offshore HVDC substations and up to three accommodation platforms) and up to 2,113 km of array cables (including substation interconnector cables) and export cables. Estimated to be up to 11,566 vessel round trips during the decommissioning phase.	Maximum vessel traffic movements will be associated with greatest turbine numbers (and associated infrastructure). Total number of vessel movements is assumed to be the same as during the construction phase.
Increased suspended sediments arising from decommissioning activities such as cable and foundation removal may impair the foraging ability of marine mammals.	Increases of SSC associated with the removal of up to 361 foundations (i.e. up to 342 turbines, up to 12 offshore HVAC collector substations, up to four offshore HVDC substations/offshore HVAC booster stations and up to three accommodation platforms) and up to 2,113 km of cables (1,038 km of subtidal export cable (i.e. six x 173 km cables), 850 km of array cable, and 225 km interconnector cable).	Maximum design scenario as per the construction phase and assumes removal of all foundations and all subtidal and intertidal cables.

Potential impact	Maximum design scenario	Justification
Accidental pollution released during decommissioning (including decommissioning 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 compound, heavy metal and hydrocarbon contamination resulting from up to 361 foundations (i.e. up to 342 WTGs, up to 12 offshore HVAC collector substations, up to four offshore HVDC substations and up to three accommodation platforms) and up to 2,113 km of cables (1,038 km of subtidal export cable (i.e. six x 173 km cables), 850 km of array cable, and 225 km interconnector cable). Accidental pollution may arise from vessel activity from up to 11,566 round trips to port by vessels over the decommissioning period.	These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during decommissioning and the offshore storage of fuel. Contamination of intertidal habitats could lead to pollution effects within the marine food chain, therefore affecting higher trophic level predators, such as marine mammals.
Changes in the fish and shellfish community resulting from impacts during decommissioning may lead to loss of prey resources for marine mammals.	Changes in the fish and shellfish community associated with all decommissioning activities including: • Temporary habitat loss/disturbance totalling 23,433,040 m^2; • Temporary increases in SSC from removal of up to 361 foundations and 2,113 km of cables (1,038 km of subtidal export cable (i.e. six x 173 km cables), 850 km of array cable, and 225 km interconnector cable); • Sediment deposition (as above for suspended sediment); • Subsea noise from decommissioning of up to 361 foundations and 2,113 km of cables; • Loss of hard substrates and structural complexity (1,595,791 m^2 based on 361 gravity base foundations); • Habitat alteration (due to presence of scour and cable protection left *in situ*) totalling 3,047,670 m^2; and • Accidental release of pollutants from decommissioning of up to 361 foundations and from vessels used during the decommissioning phase (up 11,566 round trips).	Maximum design scenario as per decommissioning phase in chapter 3: Fish and Shellfish Ecology.

Table 5.3: 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 11,566 (4,446 + 3,420 + 304 + 2,856 + 540) vessel movements during construction, comprised of: • Up to 4,446 vessel movements (3,420 + 304 + 2,825 + 540) over construction period based on gravity base foundations (self-installing concept); • Up to 3,420 vessel movements (342 installation vessel movements + 2,052 support vessel movements + 1,026 transport vessel movements), over construction period for Wind Turbine Generator (WTG) installation; • Up to 304 vessel movements over construction period for substations; • Up to 2,856 vessel movements over construction period for array cables; and; • Up to 540 vessel movements over construction period for export cable. o The offshore components of Hornsea Three will occur over a maximum duration of 11 years, assuming a two phase construction scenario. A gap of six years may occur between the same activity in different phases. 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 342 monopile foundations of 7 m diameter; • Piling of up to 19 monopile foundations, 15 m diameter, for substations and platforms including: o Three offshore accommodation platforms; o Twelve offshore HVAC collector substations; and	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 a 11 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 three phase partially-parallel construction

Potential impact	Maximum design scenario	Justification
	o Four offshore HVAC booster stations (located within the offshore HVAC booster station search area. • Total number of monopiles 361 (342 + 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; • Maximum 8 hours piling duration per monopole, although average duration of piling is likely to be 2.5 hours per pile (including 30 minute soft start); • 24 hour pile driving (assumed to be one monopile installed per 24 hours but can up to two installed) • Maximum total duration of actual piling 2,888 hours (8 x 361); • Piling is likely to occur on 361 days phased over a 2.5 year piling phase (allowing for breaks between piling events and contingency days – both estimated as 24 hour periods); and • Concurrent piling using two vessels located at opposite ends of the site. Offshore cables: 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 six years between phases. Therefore the maximum duration over which export cables could be installed is nine years. Installation of 1,038 km of export cables (six cable trenches 173 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 850 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. Maximum construction activity duration Foundations when using Jacket foundations with single piling • Piling of up to 342 4 m diameter jacket foundations (four piles per foundation), with up to 1,368 piles (342 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 four piles per leg), with up to 72 piles (3 x 24) in total; o Twelve offshore HVAC collector substations (six legs with four piles per leg), with up to 288 piles (12 x 24) in total; and o Four offshore HVDC converter substations (72 piles per foundation) with up to 288 piles (4 x 72) in total. • Total number of pin piles 2,016 (1,368 + 72 + 288 + 288); • 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 8 hours piling duration per pile although average duration of piling is likely to be 2.5 hours per pile (including 30 minute soft start); • Maximum total piling duration 16,128 hours of piling (8 x 2,016); • 24 hour pile driving (assumed to be four jacket piles but can be up to eight installed per 24 hours); • *Piling is likely to occur on 433 days phased over a three year piling phase (allowing for breaks between piling events and contingency days – both estimated as 24 hour periods); and,* • Single vessel piling only.	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
	Offshore cables: 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 six years between phases. Therefore the maximum duration over which export cables could be installed is nine years. Installation of 1,038 km of export cables (six cable trenches 173 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 850 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.	
Operation 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 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 342 WTGs), within the total wind farm area of 696 km^2, with a minimum of 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore HVAC collector 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.
Mortality from collision with rotating turbine blades	Operation of maximum number of turbines (up to 342 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 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 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 2,832 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 (87 return trips per year over the design life of the project (i.e. 25 years). Up to 25,234 helicopter flights per year comprising of: 22,572 wind turbine visits; 1,102 platform visits; and 1,560 crew shift transfers.	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.
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 342 WTGs, 12 offshore HVAC collector substations, three offshore accommodation platforms, four offshore HVDC substations or four offshore HVAC booster stations (located within the offshore HVAC booster station search area); Up to 1,038 km of export cable and 850 km array cables; and Up to 11,026 return vessel trips for up to 153 vessels over the decommissioning phase.	Provides for the largest possible noise over the greatest spatial extent of the Hornsea Three site, over the largest temporal scale.

Table 5.4: Maximum design scenario considered for the assessment of potential impacts on onshore ecology.

Potential impact	Maximum design scenario	Justification
Construction phase		
Potential for construction of landfall cable to adversely impact Weybourne Cliffs SSSI. (geological SSSI: impact assessed in Vol 3, Chapter 1: Geology and ground conditions)	<u>Hornsea Three landfall</u> Open cut techniques installing up to eight cables with a corridor up to 20 m either side of each cable. The width of the corridor at landfall would be up to 20 m either side of each cable. Up to eight transition joint bays of total up to 2,000 m^2 (250 m^2 x 8).	Use of open cut techniques within SSSI could cause damage to geological features. Open cut techniques are more damaging than trenchless techniques.
Potential for open cut trenching and installation of cables to cause habitat loss within designated sites	Permanent onshore cable corridor area is 3,300,000 m^2 (60 m wide and 55 km long). Up to six cable trenches (each containing one circuit) each trench is 5 m wide and 2 m deep. Depth of stabilised backfill up to 1.5 m. Up to 330 junction bays and link boxes. Closest separation distance between junction bay and link box: - 750 m. Up to 74,250 m^2 area required for junction bays (based on 330 junction bays (each junction bay is 9 m x 25 m)). Up to 2,970 m^2 area required for link boxes (based on 330 link boxes (each link box: is 3 m x 3 m)). Up to two temporary haul roads 5 m wide (7 m wide at passing places). Maximum duration of works for three-phase partially parallel construction programme is c.11 years Minor watercourses and drainage channels to be crossed via an open cut and ducting method. The open cut cable crossing methodology is described in the in volume 1, chapter 3: Project Design.	
Potential for open cut trenching and installation of cables to cause loss of hedgerow habitat		Open cut trenching could result in loss or damage of habitat. Open cut techniques are more damaging than trenchless techniques. The maximum design scenario for ecology on the onshore export cable corridor is the HVAC transmission due to the greater number of cable trenches required and therefore, the greatest area of land disturbance. Maximum design scenario of three-phase cabling operation over 11 year period would delay permanent restoration of habitats and therefore represents the worst case for assessment.
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 loss, damage to and disturbance of ponds		
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 damage to designated sites from run-off pollutants		
Potential for open cut trenching and installation of cables to cause damage to habitats from run-off pollutants		
Potential for open cut trenching and installation of cables leading to habitat loss and/or severance for a number of species		Open cut techniques are more damaging than trenchless techniques. Loss of habitat for protected or other species such as GCN, reptiles, breeding birds, bats, water voles, badgers. Severance of hedgerows could affect foraging and commuting behaviour for mobile species such as bats. The maximum design scenario for ecology on the onshore export cable corridor is the HVAC transmission due to the greater number of cable trenches required and therefore, the greatest area of land disturbance. Maximum adverse scenario of three-phase cabling operation over 11 year period would delay permanent restoration of habitats and therefore represents the worst case for assessment.
Potential for open cut trenching and installation of cables to cause habitat loss and disturbance to badgers		Open cut trenching could result in loss or damage of habitat. Open cut techniques are more damaging than trenchless techniques. The maximum design scenario for ecology on the onshore export cable corridor is the HVAC transmission due to the greater number of cable trenches required and therefore, the greatest area of land disturbance. Maximum adverse scenario of three-phase cabling operation over 11 year period would delay permanent restoration of habitats and therefore represents the worst case for assessment.

Potential impact	Maximum design scenario	Justification
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		SPA species potentially disturbed by noise, lighting, visual disturbance both within SPA and outside if present in functionally linked habitats in and around location of onshore connection. The maximum design scenario for ecology on the onshore export cable corridor is the HVAC transmission due to the greater number of cable trenches required and therefore, the greatest area of land disturbance. Maximum adverse scenario of three-phase cabling operation over 11 year period would delay permanent restoration of habitats and therefore represents the worst case for assessment.
Potential for open cut trenching and installation of cables to cause habitat loss and disturbance to other wintering birds		Wintering bird species potentially disturbed by noise, lighting and visual disturbance. The maximum design scenario for ecology on the onshore export cable corridor is the HVAC transmission due to the greater number of cable trenches required and therefore, the greatest area of land disturbance. Maximum adverse scenario of three-phase cabling operation over 11 year period would delay permanent restoration of habitats and therefore represents the worst case for assessment.
Potential for permanent habitat loss from construction of onshore infrastructure have adverse impacts on habitats	<u>Onshore HVDC converter/HVAC substation</u> Permanent area of site is 128,000 m^2 plus a temporary works area of 100,000 m^2. The transmission option with the greatest number of buildings and largest footprint is the HVDC converter station – up to five buildings. The main building (single building scenario) for the HVDC converter station will have a footprint of 11,250 m^2 (75 m x 150 m). Dimensions for the multiple building scenario would be reduced proportionately but the overall footprint would be the same. <u>Onshore HVAC booster station</u> Permanent area of site is 25,000 m^2 plus a temporary works area up to 25,000 m^2. Building scenario with the largest footprint - single building with area of 4,500 m^2 (150 m length and 30 m width) and height up to 12.5 m. HVAC booster station and onshore HVDC converter/HVAC substation structures as described in volume 1, chapter 3 Project description.	The maximum design scenario in terms of 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 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.
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 adverse impacts on wintering birds		
Potential for trenchless duct installation and cable pulling beneath watercourses to cause damage and disturbance to designated sites	Up to 50 HDD crossings across surface watercourses. A HDD compound would be located at both ends of the HDD crossing each with a footprint of up to 4,900 m^2 (70 m x 70 m) with permeable surfacing. Contamination via run-off from works as a result of spillages at trenchless technique works; and indicative onshore construction programme (including all phases and gaps between phases) of up to 11 years during which the period of excavating trenches and installing cable duct will be up to 24 months.	The maximum design scenario effects on designated sites and habitats would result from the use of trenchless techniques (e.g. HDD). Trenchless crossing techniques present a risk of indirectly contaminating surface watercourses where they are hydraulically connected with surface runoff caused by spillages and the movement of sediment.
Potential for trenchless duct installation and cable pulling beneath watercourses to cause damage and disturbance to other watercourses and habitats		
Potential for trenchless duct installation and cable pulling beneath watercourses to cause habitat loss and disturbance to protected species	Up to 50 HDD crossings across surface watercourses. A HDD compound would be located at both ends of the HDD crossing each with a footprint of up to 4,900 m^2 (70 m x 70 m) with permeable surfacing. Indicative onshore construction programme (including all phases and gaps between phases) of up to 11 years during which the period of excavating trenches and installing cable duct will be up to 24 months	The maximum design scenario effects on designated sites and habitats would result from the use of trenchless techniques (e.g. HDD). Trenchless crossing techniques present a risk of indirectly contaminating surface watercourses where they are hydraulically connected with surface runoff caused by spillages and the movement of sediment. Maximum adverse scenario of three-phase cabling operation over 11 year period would delay permanent restoration of habitats and therefore represents the worst case for assessment.

Potential impact	Maximum design scenario	Justification
Potential for construction of onshore infrastructure to have adverse impacts on designated sites from airborne pollutants	Onshore HVDC converter/HVAC substation Permanent area of site is 128,000 m^2 plus a temporary works area of 100,000 m^2. The transmission option with the greatest number of buildings and largest footprint is the HVDC converter station – up to five buildings. The main building (single building scenario) for the HVDC converter station will have a footprint of 11,250 m^2 (75 m x 150 m). Dimensions for the multiple building scenario would be reduced proportionately but the overall footprint would be the same. Onshore HVAC booster station Permanent area of site is 25,000 m^2 plus a temporary works area up to 25,000 m^2. Building scenario with the largest footprint - single building with area of 4,500 m^2 (150 m length and 30 m width) and height up to 12.5 m. HVAC booster station and onshore HVDC converter/HVAC substation structures as described in volume 1, chapter 3 Project description	The maximum design scenario in terms of 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 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..
Potential for construction of onshore infrastructure to cause damage to designated sites from run-off 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 run-off pollutants		
Potential for temporary habitat loss from construction of temporary works compounds to have adverse impacts on habitats	Construction compounds up to 33,000 m^2 (average area 17,000 m^2). Number of HDD crossings: up to 50 (to inform PEIR). A HDD compound would be provided at both ends of the HDD crossing each with a minimum area of 4,900 m^2 (70 m x 70 m). Area required for junction bay compounds – 40 m x 40 m (minimum). Temporary compounds in locations as described in volume 1, chapter 3 Project description	The maximum design scenario in terms of 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 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.
Potential for construction of temporary works compounds to have adverse impacts on designated sites from airborne pollutants		
Potential for construction of temporary compounds to cause damage to designated sites from run-off pollutants		
Potential for construction of works compounds to have adverse impacts on habitats from airborne pollutants		
Potential for construction of temporary compounds to cause damage to habitats from run-off pollutants		
Potential for temporary habitat loss from construction of works compounds to have adverse impacts on species		
Potential for temporary habitat loss from construction of works 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 two temporary roadways (haul road): Roadway width: 5 m (7 m at passing places) Roadway construction: 600m crushed aggregate on geotextile or soil stabilisation Dimensions of temporary culvert/bridge crossings for the haul road/access track. up to 4 m x 5 m wide	The maximum design scenario in terms of 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 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.
Potential for temporary habitat loss from construction of access tracks to have adverse impacts on habitats		
Potential for construction and use of access tracks to have adverse impacts on designated sites from airborne pollutants		
Potential for construction and use of access tracks to cause damage to designated sites from run-off pollutants		
Potential for construction and use of access tracks to have adverse impacts on habitats from airborne pollutants		

Potential impact	Maximum design scenario	Justification
Potential for construction and use of access tracks to cause damage to habitats from run-off pollutants		
Potential for temporary habitat loss from construction of access tracks to have adverse impacts on species		
Potential for temporary habitat loss and disturbance from construction and use of access tracks to have adverse impacts on wintering pink-footed goose		
Potential for temporary habitat loss and disturbance from construction and use of access tracks to have adverse impacts on wintering birds		
Operation phase		
Potential for operation to result in low-level visual disturbance, and noise and vibration disturbance of habitats and species during routine maintenance operations	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	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 Routine maintenance of the onshore HVDC converter/HVAC substation and HVAC booster station may involve the use of oils, greases and other substances with associated potential for accidental spillages. Oils/chemical spills to ground are worst case condition.
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	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	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 Routine maintenance of the onshore HVDC converter/HVAC substation and HVAC booster station may involve the use of oils, greases and other substances with associated potential for accidental spillages. Oils/chemical spills to ground are worst case condition.
Decommissioning phase		
Potential for decommissioning of cables to affect designated sites	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.	The maximum design scenario condition assumed is cables left in situ, de-energised and capped with an appropriate material.
Potential for decommissioning of cables to affect habitats		The maximum design scenario condition assumed is cables left in situ, de-energised and capped with an appropriate material.
Potential for decommissioning of cables to affect species		The maximum design scenario condition assumed is cables left in situ, de-energised and capped with an appropriate material.
Potential for decommissioning of HVAC booster station and onshore HVDC converter/HVAC substation to affect designated sites		The maximum design scenario condition assumed is cables left in situ, de-energised and capped with an appropriate material.
Potential for decommissioning of HVAC booster station and onshore HVDC converter/HVAC substation to affect habitats		The maximum design scenario condition assumed is cables left in situ, de-energised and capped with an appropriate material.
Potential for decommissioning of onshore HVDC converter/HVAC substation and HVAC booster station to affect species		The maximum design scenario condition assumed is cables left in situ, de-energised and capped with an appropriate material.

5.3 Project designed-in mitigation

5.3.1.1 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 Draft Report to Inform Appropriate Assessment. These measures are considered standard industry practice for this type of development. Relevant designed-in mitigation measures relating to Annex I habitats, Annex II marine mammals, offshore ornithology and onshore European site qualifying features are detailed below in Table 5.5 to Table 5.8.

Table 5.5: Designed-in measures adopted as part of Hornsea Three – offshore Annex I habitats.

Measures adopted as part of Hornsea Three	Justification
Pre-construction surveys will be undertaken along the Hornsea Three offshore cable corridor to identify benthic habitats of conservation, ecological and/or economic importance. Should Annex I reef habitat be identified during pre-construction surveys of the Hornsea Three offshore cable corridor, appropriate mitigation will be discussed with statutory consultees to avoid direct impacts to these features (where appropriate this may include micro-siting). This approach is typical for offshore wind farm and cable developments.	Annex I reefs were not identified at the Hornsea Three array area, *S. spinulosa* aggregations assessed as being 'low reef' identified within the Hornsea Three offshore cable corridor during the site specific survey and *S. spinulosa* are reefs known to occur within this part of the southern North Sea benthic ecology study area. Direct impacts (e.g. habitat loss) to ecologically sensitive Annex I biogenic (e.g. *S. spinulosa*) reefs are to be avoided and given the evidence for the propensity for reef to develop in this area, pre-construction surveys will identify the presence of such reefs and ensure that measures can be designed, if necessary, to avoid direct impacts. Similarly, exposed chalk features, which may be determined as Annex I reefs, are known to be present in the nearshore waters off the coast of north Norfolk. [a] Pre-construction surveys will investigate locations of such habitats and Hornsea Three will continue to investigate the feasibility of avoiding these features as the project progresses.
A CoCP will be developed and implemented to cover the construction phase and an appropriate PEMMP will be produced and followed to cover the operation and maintenance phase of Hornsea Three. The latter will include planning for accidental spills, contain a biosecurity plan to limit the spread of INNS, address all potential contaminant releases and include key emergency contact details (e.g. 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 wind farm development.

Table 5.6: Designed-in measures adopted as part of Hornsea Three – marine mammals.

Measures adopted as part of Hornsea Three	Justification
A CoCP (construction phase), PEMMP (operation phase) and Decommissioning Plan (decommissioning phase) will be produced and followed (Table 5.6). The CoCP, 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 be buried to a target burial depth of 1 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 Table 5.3) 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 750 kJ (soft-start hammer energy) as agreed with the Marine Mammal EWG.
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.

Table 5.7: 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 Code of Construction Practice (CoCP) will be developed and implemented to cover the construction phase. A Project Environmental Management and Monitoring Plan (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 (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 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 5.8: Designed-in measures adopted as part of Hornsea Three – onshore ecology.

Measures adopted as part of Hornsea Three	Justification
Design measures	
Consideration of use of trenchless installation method beneath major 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 cable route corridor has been developed to avoid areas of woodland and other ecologically sensitive habitats wherever practicable.	To minimise loss of habitats of conservation interest
Other VER features such as ponds and LWSs have been avoided in the selection of the cable route alignment and local features such as standard trees 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 cable route alignment to provide an appropriate buffer from construction and operational works. The width of these buffer zones are: for nesting birds will be developed in accordance with standard industry requirement and best practice guidance, and is expected to be applied for 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 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 cable route 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 six 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. NE 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 enable refinements to be made to the construction programme to take into account any changes in the distribution or presence of notable species.
Surveys will include pre-construction surveys 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 trenchless installation will be undertaken across a watercourse where water voles, Desmoulin's whorl snail, white-clawed crayfish and/or otters have been recorded, a detailed method statement will be developed in order to help ensure the protection of these species. The method statement will be agreed with NE prior to the commencement of works. The method statement will include detailed pre-construction measures designed to ensure that impacts on these species are minimised (e.g. through relocation of animals from the works corridor and an adjacent buffer zone). The method statement will include post-construction habitat restoration and management requirements.	To help ensure the protection of water voles, Desmoulin's whorl snail, white-clawed crayfish and/or otters during construction and minimise the impacts of construction on the long-term viability of populations.
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. 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 trenchless installation launch pits will be located, using bird scarers.	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 trenchless 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 an NE 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 NE, 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 an outline CoCP, which will be pre-approved by the LPAs. The CoCP will be prepared at the Final Environmental Statement stage.	To minimise the likely impacts on ecology and nature conservation features of interest.
Site induction and toolbox talks will include mitigation requirements included in this chapter and the outline EMP.	To help ensure adherence to the ecology mitigation strategy and protection of habitats and species of nature conservation interest.

Measures adopted as part of Hornsea Three	Justification
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 so 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.
At the landfall, cable installation will be by trenchless method beneath Weybourne Cliffs SSSI.	To minimise impacts on feature of geological interest
Night working will be avoided where practicable. However it may be necessary to carry out works during night time hours, such as during trenchless installation operations and cable pulling, 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 ground water-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.
Further details of measures relating to pollution prevention will be 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.	To minimise the potential for pollution incidents to effect habitats.

Measures adopted as part of Hornsea Three	Justification
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, or 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 cable route 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 cable route. In addition, enhancement planting to improve connectivity and/or native species diversity will be considered on a case by case basis. along the cable route. Enhancement planting will include the planting of native hedgerow trees, typical of the area, at a suitable distance from the cable route. A replanting programme to compensate for habitat lost and provide screening will be carried out at the proposed HVAC booster station and onshore HVDC converter/HVAC substation sites. Planting and management of reinstated areas will be undertaken in accordance with an outline EMP. Detailed landscaping proposals will be developed in an outline Landscape Scheme and Management Plan. Planting will be undertaken as soon as practicable and once it could 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 NE, 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.

Measures adopted as part of Hornsea Three	Justification
In addition to measures to minimise the potential for pollution incidents, options for trenchless installation will be considered at: • 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; and • Intwood Stream. Other locations for trenchless installation are being considered and may be identified following the completion of species surveys. Locations being considered include: • Kelling Heath SSSI; • Low Common CWS; • Old Hall Meadow CWS; and • River Glaven headwaters and tributaries. Where trenchless 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. Open cut trenching across watercourses known to support water voles (if required) will be undertaken in accordance with the NE approved method statement. Where considered necessary by the ECoW, high visibility fencing will be erected between the drains and the works areas to prevent access by workers and heavy machinery, and also to prevent storage of equipment or materials within this zone. To prevent water voles from becoming trapped in the trenchless installation pits, exclusion fencing will be installed around trenchless installation pits where considered necessary by the ECoW.	To minimise the potential impacts on water voles and otters.

Measures adopted as part of Hornsea Three	Justification
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. Where water vole activity has been/is recorded along watercourses to be crossed by open cut installation, construction and installation works will be carried out in accordance with a detailed method statement developed so as to protect water voles against injury, death and significant disturbance. 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 cable route corridor, to control the movement of personnel and vehicles. Works will be conducted in accordance with NE 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" (English Nature, 2001) Works will also take into account best practice guidelines published in Strachan *et al.*(2011).	To minimise the potential impacts on water voles.

Measures adopted as part of Hornsea Three	Justification
In addition to measures to minimise the potential for pollution incidents, cable installation will be undertaken by trenchless installation beneath watercourses of value to otters, if identified during surveys. Trenchless 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. Trenchless installation launch pits will be located at a minimum distance from known otter holts, and construction compounds and storage areas will be located a minimum distance from any otter holts. Works-free buffer zones will be set up around the holt 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 cable route 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 NE 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 NE 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 an active sett entrance. Works within 30 m of a badger sett entrance may require an NE 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 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.

Measures adopted as part of Hornsea Three	Justification
If work within minimum distances of a sett and therefore, sett closure or disturbance cannot be avoided, this will need to be carried out outside the badger breeding season (defined as 30 November to 1 July) and in accordance with an NE approved method statement and where relevant an NE licence for badgers. Trenchless installation launch pits will be located minimum distances from active badger setts, or an NE 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 cable route corridor, or in the areas around the trenchless installation launch sites, micrositing away from the setts will be undertaken where practicable within the consented boundary of development, or an NE licence for badgers may be required before works continue.	To minimise the potential impacts on badgers.
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 will be included in the outline CoCP. These measures will 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 NE; and • Use of temporary 'artificial bridges' to provide a link between severed edges of hedgerows and other habitat crossed by the cable route 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.
Post-construction measures	
Reinstatement of damaged or cleared terrestrial habitat will be carried out as soon as practicable. Habitat reinstatement in consultation with LPAs will involve the replacement following cable installation, of stripped soils and the planting of native hedgerows, shrubs and trees, typical of the local area and of local provenance where possible. Agricultural habitats will be reinstated. The construction of buildings and planting of trees with deep roots will not be permitted above the cable systems to prevent potential damage to cabling. Habitat reinstatement will be undertaken in accordance with a pre-approved Landscape Scheme and Management Plan. The scheme will include the retention and/or replacement of habitats of nature conservation value wherever practicable.	In order to minimise the period of time that habitats and species will be affected.

Measures adopted as part of Hornsea Three	Justification
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 Schwegler 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; • 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.
Post-construction restoration on affected watercourses will be carried out to reinstate banks to their previous condition, and ensure suitable for water voles.	To minimise the potential impacts on water voles.
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 volume 3, chapter 2: Hydrology and Flood Risk.	To protect retained habitats and species.
Habitats will be managed in accordance with the outline EMP and the outline Landscape Scheme and 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.	To minimise likely impacts on habitats and species of ecological or conservation interest.

5.4 Approach to in-combination assessment

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

5.4.1.2 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 National Infrastructure's Planning Inspectorate's programme of Projects;

- 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.

5.4.1.3 Projects falling into the above categories were considered for inclusion within the CEAs presented for each topic chapter within the PEIR. In order to ensure consistency between assessments this approach has been taken forward in the Draft Report to Inform Appropriate Assessment.

5.4.1.4 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.

5.4.1.5 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.

5.4.1.6 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.

5.4.1.7 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.

5.4.1.8 It should be noted that the in-combination assessments presented in this Draft Report to Inform Appropriate Assessment 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 Draft Report to Inform Appropriate Assessment . In addition, Hornsea Three is currently considering how the different levels of certainty associated with projects in Tier 1 can be reflected in the CEA and subsequently the Draft Report to Inform Appropriate Assessment in-combination assessment, and an update, in terms to the approach to tiering, will be presented in the Environmental Statement.

5.4.1.9 A long list of relevant projects, plans and activities occurring within a large study area encompassing the entire southern North Sea (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 the southern North Sea and parts of Norfolk, 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 PEIR, 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.

5.4.1.10 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.

6. Assessment of Adverse Effects on Integrity: Offshore Annex I Habitats

6.1 Introduction

6.1.1.1 The screening exercise (Stage 1 of the HRA process), and subsequent evaluation in Section 4.4.1, identified potential for LSEs on the Annex I habitats features of the North Norfolk Sandbanks and Saturn Reef SCI as indicated in Table 6.1 and shown in Figure 6.1.

6.1.1.2 This Draft 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 will be submitted as part of the Application for Development Consent.

6.1.1.3 Following the approach taken in Hornsea Project 1 and Project 2 HRA, the assessment criteria and conclusions presented within the PEIR 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.

6.2 Conservation Objectives

6.2.1.1 Appropriate Assessment 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 Sandbanks and Saturn Reef SCI, with regard to the habitats for which the site has been designated, are as follows (JNCC, 2015):

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.

6.2.1.2 Specifically, in relation to this site, the Conservation Objectives are to restore the following Annex I habitats to favourable condition:

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

6.2.1.3 JNCC (2012) indicated that subject to natural change, these habitats should be restored to favourable conditions, such that:

- The natural environmental quality, natural environmental processes and extent are maintained; and
- The physical structure, diversity, community structure and typical species, representative of sandbanks which are slightly covered by seawater all the time and reefs in the Southern North Sea are restored.

6.3 Potential impacts

6.3.1.1 The potential effects on benthic features for each potential impact screened into the assessment (Table 6.1) have been described in the PEIR Volume 2, Chapter 2: Benthic Ecology and are summarised in Table 6.2.

Table 6.1: European sites and features for which LSE cannot be discounted – Annex I habitats (offshore).

Site	Feature	Project phase	Potential Impact
North Norfolk Sandbanks and Saturn Reef SCI	• 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
		Operation	• Long-term habitat loss • Colonisation of hard structures • Changes in physical processes • Temporary seabed disturbance • Accidental pollution

Table 6.2: 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	Long-term habitat loss	There is the potential for 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	

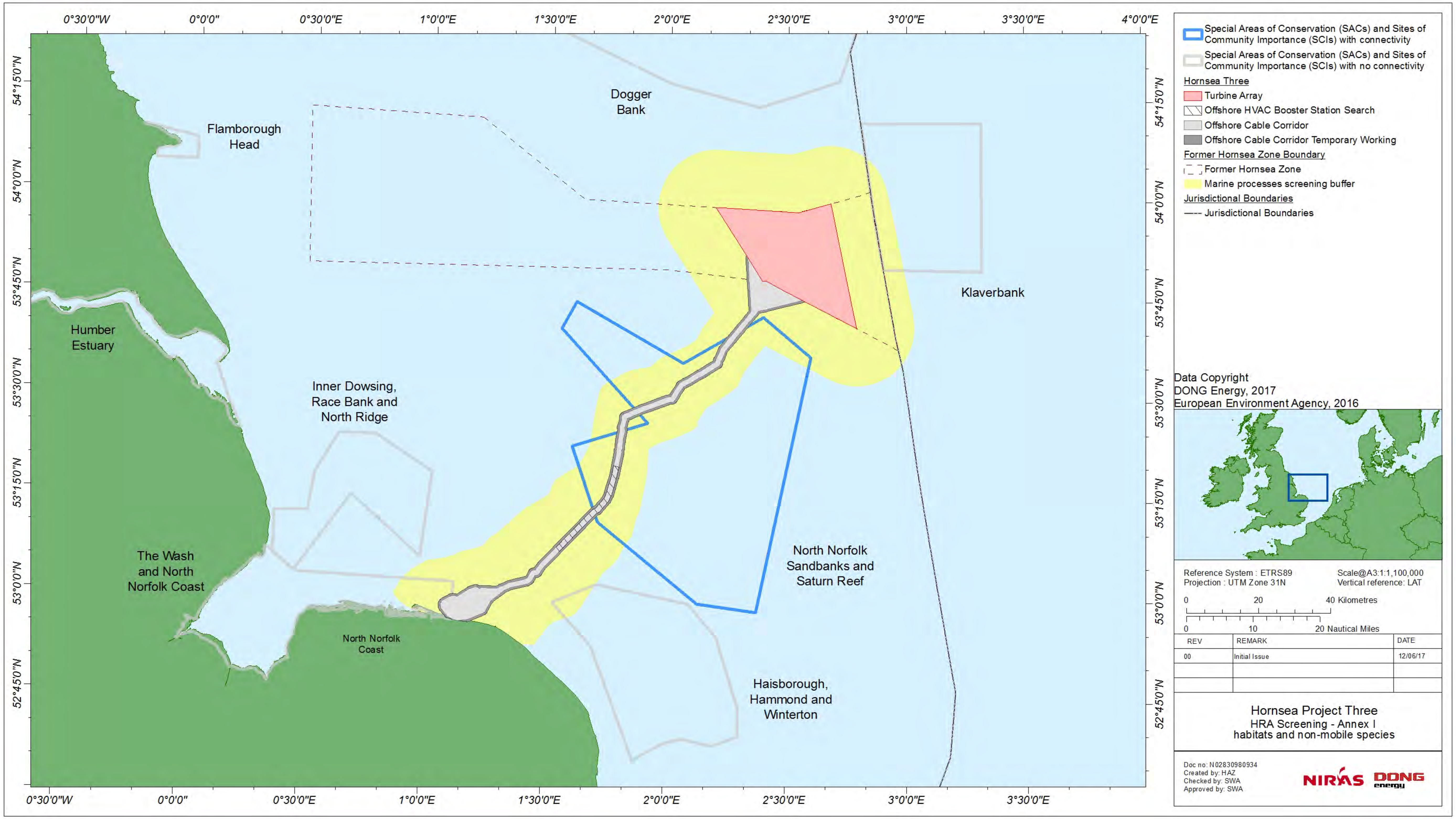

Figure 6.1: European sites in relation to Hornsea Three.

6.4 Baseline information

6.4.1 Methodology to inform baseline

6.4.1.1 Baseline information on the Annex I habitat features of the European Site identified for further assessment within the HRA process has been gathered by a combination of desktop studies, data from benthic surveys undertaken within the North Norfolk Sandbanks and Saturn Reef SCI 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 North Norfolk Sandbanks and Saturn Reef SCI and context from the wider area.

6.4.1.2 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 *S. spinulosa* structures (Jenkins *et al.*, 2015). Geophysical acquisition, DDV and grab sampling was performed throughout the North Norfolk Sandbanks and Saturn Reef SCI 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.

6.4.2 Evidence Plan

6.4.2.1 The Evidence Plan process has been set out in the Hornsea Project Three Offshore Wind Farm – Evidence Plan, the purpose of which is to agree the information Hornsea Three needs to supply to the Planning Inspectorate (PINS), as part of a DCO application for Hornsea Three. The Evidence Plan HRA.

6.4.2.2 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 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 PEIR, a number of EWG meetings were held that included discussion of key issues with regard to the benthic ecology elements of Hornsea Three, including characterisation of the baseline environment and the impacts to be considered within the impact assessment.

6.4.2.3 The Hornsea Three array area is located within the former Hornsea Zone, for which extensive data and knowledge regarding benthic ecology 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. It was therefore proposed that the Hornsea Three benthic ecology characterisation of the Hornsea Three array be completed using a combination of desktop data and information sources, and historic survey data collected as part of the characterisations of the Hornsea Project One and Hornsea Project Two offshore wind farms and the former Hornsea Zone.

6.4.2.4 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. Site-specific surveys were completed in 2016 and a further site-specific survey of the Hornsea Three offshore cable corridor will be undertaken in Q3 2017. Together with the existing data, this survey will be used to establish a robust and up-to-date characterisation of the baseline environment in the Hornsea Three offshore cable corridor. This site-specific Hornsea Three offshore cable corridor survey has been discussed and agreed through the Marine Processes, Benthic Ecology and Fish and Shellfish EWG. The results will be used to update the Hornsea Three benthic ecology baseline characterisation where relevant within the final Report to Inform Appropriate Assessment .

6.4.3 Desktop study

6.4.3.1 Information on benthic ecology was collected through a detailed desktop review of existing studies and datasets. The key data sources are summarised in Table 6.3, although this should not be considered an exhaustive list of references. Further detail is presented within PEIR volume 5, annex 2.1: Benthic Ecology Technical Report.

6.4.4 Site specific surveys

6.4.4.1 Recent survey data collected from the Hornsea Three array area and Hornsea Three offshore cable corridor in 2016, 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 volume 5, annex 2.1: Benthic Ecology Technical Report).

6.4.4.2 A further benthic ecology survey of the Hornsea Three offshore cable corridor will be undertaken in Q3 2017 (Figure 6.2). Together with the existing data, this survey will be used to establish a robust and up-to-date characterisation of the baseline environment in the Hornsea Three offshore cable corridor. This Hornsea Three offshore cable corridor survey has been discussed and agreed through the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology EWG. A summary of the surveys undertaken to date, together with the Hornsea Three benthic ecology survey planned for 2017, is outlined in below (Table 6.4).

Table 6.3: 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 6.4: Summary of benthic ecology surveys undertaken and proposed.

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	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	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	Volume 5, annex 2.1: Benthic Ecology Technical Report
Site specific surveys within the Hornsea Three benthic ecology study area					
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	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	Volume 5, annex 2.1: Benthic Ecology Technical Report
Hornsea Three intertidal survey of the landfall area	Hornsea Three landfall area (mean low water spring (MLWS) to MHWS)	Phase I walkover habitat survey habitat with 0.1 m² dig-over sampling	RPS Energy	2016	Volume 5, annex 2.1: Benthic Ecology Technical Report
Proposed site specific survey within the Hornsea Three benthic ecology study area					
Hornsea Three benthic sampling survey	Hornsea Three offshore cable corridor and three sampling stations in Markham's Hole within the Hornsea Three array area	16 combined DDV and Hamon grab sampling stations , plus 5 stations for Day grab sampling only, and 15 stations for DDV transects only	Gardline	Proposed for 2017	Volume 5, annex 2.1: Benthic Ecology Technical Report (for proposed sampling strategy only)

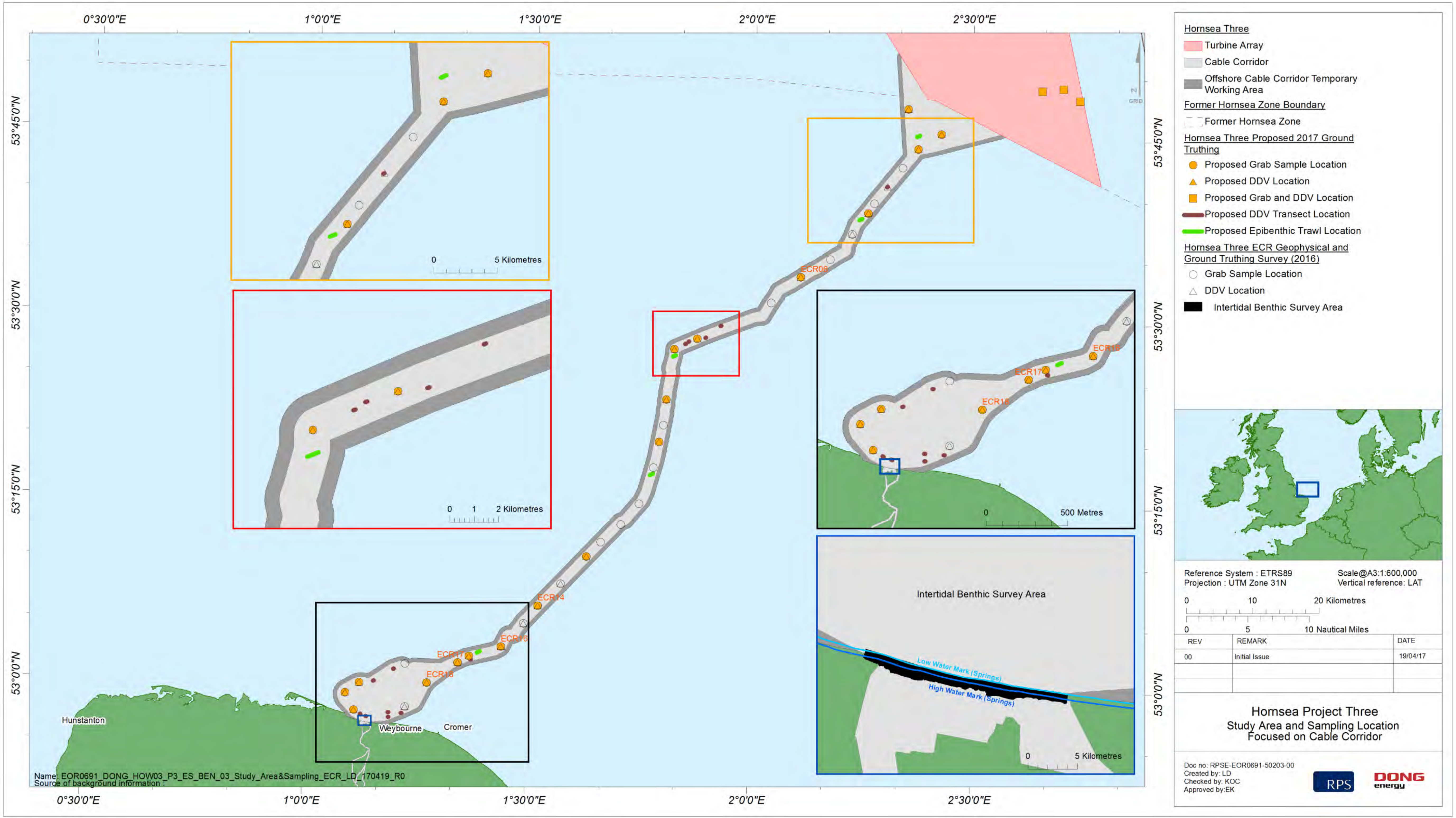

Figure 6.2: Hornsea Three offshore cable corridor with Hornsea Three (2016) benthic ecology sampling locations and benthic ecology sampling locations proposed for 2017 (benthic grabs, DDV and trawls).

6.4.5 Norfolk Sandbanks and Saturn Reef SCI Features

6.4.5.1 The North Norfolk Sandbanks and Saturn Reef SCI extends from approximately 40 km off the north Norfolk coast out to approximately 110 km offshore, covering an area of 3,603.41 km^2. The site encompasses what is considered to be the most extensive area of offshore linear ridge sandbanks in the UK (JNCC, 2010a). 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). The site is also supports biogenic reefs of *S. spinulosa* .

6.4.5.2 The North Norfolk Sandbanks and Saturn Reef SCI coincides with part of the central and seaward section of the Hornsea Three offshore cable corridor (Figure 6.1) and has been proposed for designation for the Annex I habitats 'sandbanks which are slightly covered by sea water all the time' and 'reefs'.

Sandbanks which are slightly covered by seawater all the time

6.4.5.3 Overall six sandbanks were investigated, three of the most inner sandbanks (Leman Bank, Inner Bank and Wells bank), adjacent to the central section of 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 (see Figure 6.3). Despite the range in distance between the southern and northern extents of the site, the area within the North Norfolk Sandbanks and Saturn Reef SCI 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 (Tappin *et al*., 2011; EMODNET, 2017).

6.4.5.4 Sampling on the sandbanks during the Cefas/JNCC survey revealed very subtle differences in the particle size across the profiles of the sandbanks (Jenkins *et al.*, 2015). 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 considered to comprise of slightly higher coarse and mud content compared to the flanks and crests.

6.4.5.5 An analysis of the infaunal communities revealed that numbers of taxa and abundances increased with depth throughout the SCI, and that species richness was highest in the troughs of the sand banks and lowest on the crests. ANOSIM tests revealed 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, indicating a substantial overlap in faunal composition between nearshore and offshore communities (Jenkins *et al.*, 2015). The apparently small differences in faunal communities supports the broad patterns concluded from HADA MAREA (HADA, 2012) and REC datasets (Tappin *et al*., 2011) for this region, in that biotopes did not vary considerably with distance from the shore. Statistically significant, but very small, 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).

Reefs

6.4.5.6 The presence of the Saturn *S. spinulosa* biogenic reef within the North Norfolk Sandbanks and Saturn Reef SCI was first recorded in 2002 (JNCC, 2008), within 100 m of the edge of the Hornsea Three offshore cable corridor search area. 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 *S. spinulosa* reef proposed as possible factors associated with its apparent disappearance (JNCC, 2010a).

6.4.5.7 However, in 2013, Cefas undertook another survey of the SCI 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 *S. spinulosa* biogenic structures. The 2013 data show the latest structures to overlap with the proposed Hornsea Three offshore cable corridor (Figure 6.4).

6.4.5.8 For the investigation into biogenic reef features within the North Norfolk Sandbanks and Saturn Reef SCI, 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 SCI site, which coincided with the central section of the Hornsea Three offshore cable corridor. Six patches of S. spinulosa, with generally 'low reef' quality (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 in Figure 6.4, together with the previously known position and extent of the Saturn Reef (indicated by the dark green area adjacent to the proposed DDV survey transect ECR36). This data has revealed a potential westward migration of the Saturn reef or, more likely, the loss of the original reef feature and the development of a new reef structure, demonstrating to the ephemeral nature of Sabellaria aggregations.

6.4.5.9 Areas of known and potential reef were mapped with a precautionary approach to ensure that potential reef areas were captured; as such the delineated boundaries shown in Figure 6.4 should be interpreted as being coarsely indicative and potentially over-representative of *S. spinulosa* extent. These *S. spinulosa* aggregations were considered to be highest quality biogenic features that had been recorded during the 2013 survey (Jenkins *et al.*, 2015).

6.4.5.10 The occurrence of Sabellaria biotopes throughout the Hornsea Three offshore cable corridor, together with other data such as the Humber REC data and the HADA MAREA data which indicates a wide distribution throughout this part of the southern North Sea benthic ecology study area (Hornsea Three Benthic Ecology Technical Report, 2017), 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 these areas and in the Hornsea Three offshore cable corridor is evident. It is therefore concluded that there is potential for reefs to occur within discrete parts of the Hornsea Three benthic ecology study area (namely the Hornsea Three offshore cable corridor) if suitable conditions prevail.

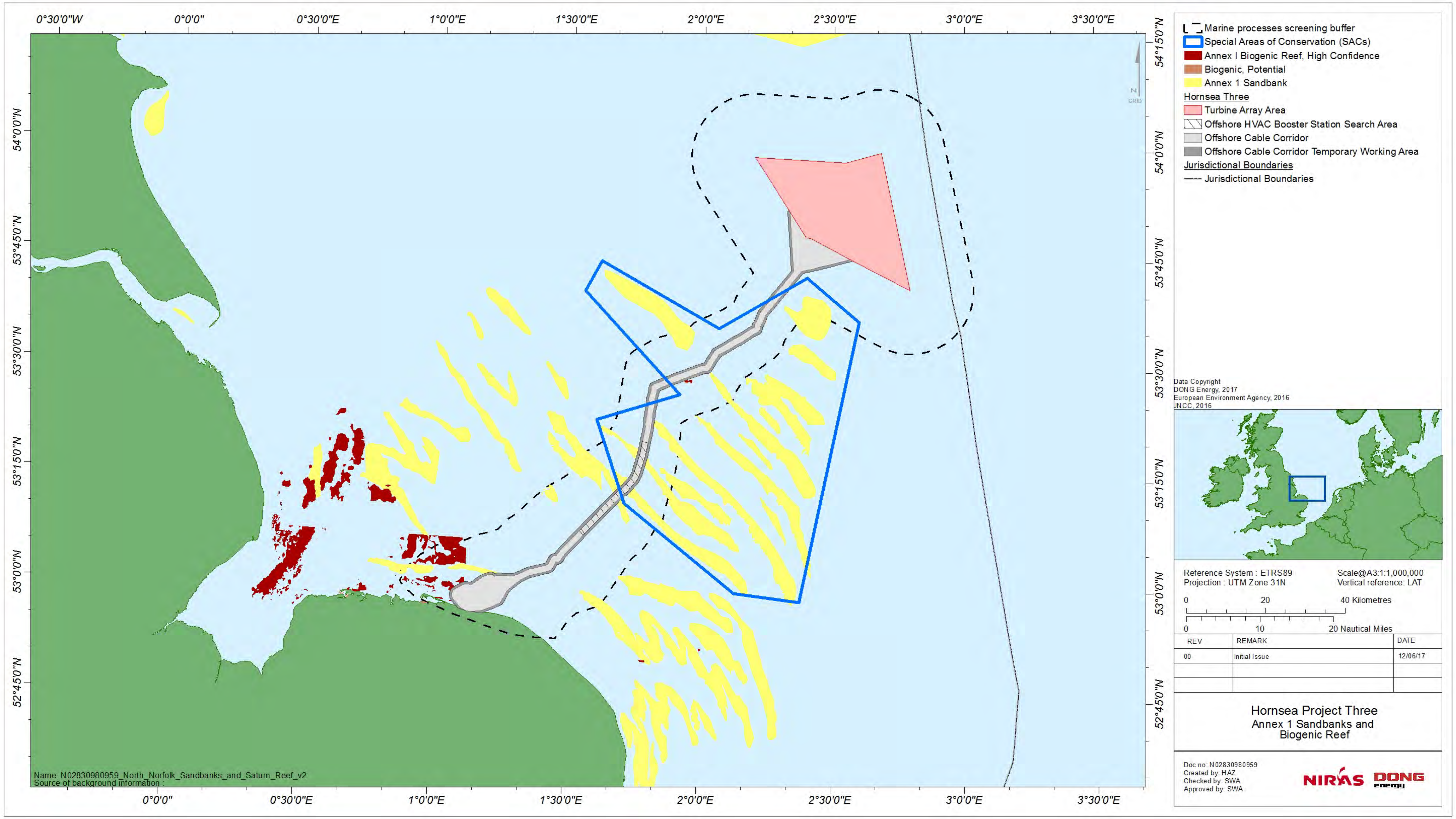

Figure 6.3: European sites designated for Annex I habitats within the ZoI of Hornsea Three and distribution of sandbanks and reef Annex I habitat.

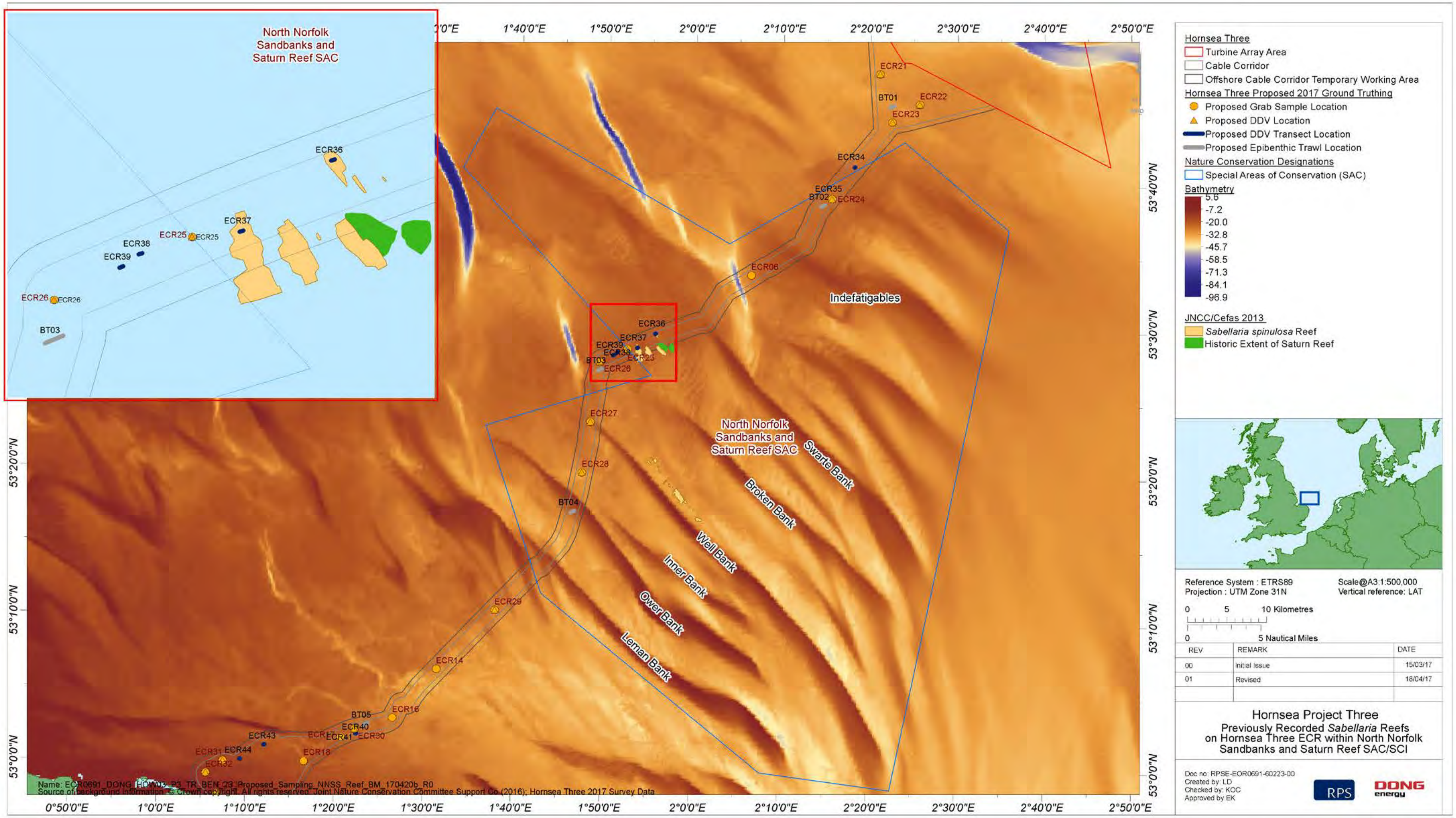

Figure 6.4: The Hornsea Three offshore cable corridor and Sabellaria reefs recorded during a survey undertaken by Cefas in 2013.

6.5 Assessment of Adverse Effects on Integrity – Alone

6.5.1 Potential impacts - construction/decommissioning

6.5.1.1 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

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

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

6.5.1.4 Of the total temporary habitat loss/disturbance described in Table 5.1, a maximum of 15,175,712 m^2 will be temporarily lost from the subtidal areas of the Hornsea Three offshore cable corridor as a result of cable burial and associated anchor placements and sandwave clearance activities. Of this 4,086,405 m^2 is anticipated to occur within the North Norfolk Sandbanks and Saturn Reef SCI which represents less than 0.11% of the total area of the SCI and subsequently 0.11% of the qualifying Annex I habitat features of this SCI. The release of granular material as a result of sandwave clearance along the Hornsea Three offshore cable corridor is predicted to result in depositions with a uniform thickness of 0.5 m (see PEIR Chapter 1: Marine Processes and volume 5, annex 1.1: Marine Processes Technical Report) and therefore for the purposes of this assessment, this activity has been assessed as temporary habitat loss.

6.5.1.5 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 and with no loss of seabed sediments from the local area. In the case of dredging, material will be disposed of in close proximity to the dredge location and will immediately be available again for transport at the naturally occurring rate, with no sediment volume removed from the sandwave systems overall. It should be noted that any material removed from sandwaves will comprise superficial materials, which are typically highly mobile, rather than the more stable material that forms the body of the sandwave. Due to the dynamic nature of the sandwaves within Hornsea Three, Annex I sandbanks are considered to have moderate to high recoverability (see chapter 1: Marine Processes).

6.5.1.6 The temporary loss/disturbance will be highly localised to the vicinity of the construction activity. The predominantly sand and coarse sediment habitats that are most likely to be affected are typical of, and widespread throughout, the southern North Sea.

6.5.1.7 Furthermore, direct temporary habitat loss will be avoided where possible to minimise any impact on Annex I reefs that have been ground truthed within the SCI further reducing the impact (Table 5.5 and PEIR Chapter 2: Benthic Ecology).

6.5.1.8 The results of a study funded by Natural England through the Marine Aggregate Levy Sustainability Fund (MALSF) investigating the recoverability or colonisation potential of *S. spinulosa* following cessation of aggregate extraction activities at Hastings Shingle Bank (Pearce *et al.*, 2007) found that dredging had not altered the seabed in a way that was detrimental to colonisation, and initial colonisation and development of a significant *S. spinulosa* aggregation was observed at the site within 18 months and development to a stage equivalent to the oldest aggregations observed in the area was assessed as likely to be complete within three years. It was concluded that a similar pattern could be expected in other extraction areas assuming a supply of larvae in the plankton and that the process would likely be significantly quicker in areas less hampered by trawling (Pearce *et al.*, 2007).

6.5.1.9 Any effects of habitat loss/disturbance within the construction phase will be temporary and will cease following completion of construction activities. Whilst fauna and flora will be affected, 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. *S. spinulosa* reef habitat is deemed to be of medium to high vulnerability, high recoverability and regional value. Although *S. spinulosa* is likely to recover quickly, the associated high biodiversity may take longer to recover and, as such, the sensitivity of this habitat is considered to be medium.

6.5.1.10 Sensitivity of the Annex I sandbank feature of the North Norfolk Sandbanks and Saturn Reef SCI is considered to be medium in chapter 1: Marine Processes and the benthic communities associated with these features are considered to be identical to wider sandy sediment habitat (Habitat A in PEIR Volume 2, Chapter 2: Benthic Ecology), although these are of international importance and are therefore considered to be of medium sensitivity.

6.5.1.11 There is no indication from the assessment of the likely effects of temporary habitat loss/disturbance on benthic ecology (PEIR Volume 2, Chapter 2: Benthic Ecology) 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 SCI.

6.5.1.12 For habitat loss/disturbance of sandy communities (including Annex I sandbanks) the PEIR volume 2, Chapter 2: Benthic Ecology considers anything less than five years, for both the duration of the impact plus recoverability, to be short term. In this instance, the key element of this assessment is the duration of the recoverability. In the context of the recoverability of sandy communities (which would include Annex I sandbanks), the duration of cable laying activities is 3 years and recoverability is expected within one to five years (see para 2.11.1.24 PEIR volume 2, Chapter 2: Benthic Ecology).

6.5.1.13 With regards to *Sabellaria*, it is noted within the PEIR volume 2, Chapter 2:Benthic Ecology, that individuals are generally tolerant to burial. In general terms, in order for *Sabellaria* individuals to survive they have to be buried for less than 32 days. Over 32 days, individuals will lose fitness but there will not be much impact in terms of the overall community. A short term impact can therefore be described as one that is predicted to arise for less than 32 days. Any increase in SSC and associated deposition will be subject to rapid dispersion, both laterally and vertically, to near-background levels.

6.5.1.14 Therefore, the impact of temporary loss/disturbance to Annex I features within the North Norfolk Sandbanks and Saturn Reef SCI is predicted to be short term and temporary in nature.

6.5.1.15 With respect to the Conservation Objectives for the SCI, 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 less than 0.11% of the Annex I habitat features within the SCI. 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.

Conclusion

6.5.1.16 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 SCI identified in Table 6.1 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 SCI 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

Temporary increases in suspended sediments/smothering

6.5.1.17 Sediment disturbance arising from construction activities (e.g. cable and HVAC booster station foundation installation) may result in adverse impacts on benthic communities as a result of temporary increases in suspended sediment concentrations and associated sediment deposition.

6.5.1.18 As detailed in Table 5.1 above, increases in suspended sediment concentrations (SSC) and associated sediment deposition are predicted to occur during the construction phase as a result of export cable and HVAC booster station foundation installation (including seabed preparation and sandwave clearance). PEIR 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, as detailed in Table 5.1, provided in this section.

6.5.1.19 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 5.1 and PEIR 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.

6.5.1.20 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.

6.5.1.21 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 PEIR 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.

6.5.1.22 As detailed in Table 5.1, sandwave clearance is also expected to be required along the Hornsea Three offshore cable corridor (PEIR, Volume 4, Annex 3.6 Sediment Disposal: Site Characterisation) including within the North Norfolk Sandbanks and Saturn Reef SCI. 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.

6.5.1.23 PEIR Chapter 1: Marine Processes predicted that impacts related to increases in SSC were likely to be similar to those for seabed preparation for gravity base foundation installation, with elevated SSCs in close proximity to sandwave clearance activities and lower levels, reflective of natural baseline conditions, at greater distances. It was predicted that increases in depth averaged SSC of 5-10 mg/l would extend less than 13 km upstream and downstream of the source where a trailing suction hopper dredger was used for sandwave clearance and SSC of 5-10 mg/l would extend less than 17.5 km from the source where a mass excavator tool was used.

6.5.1.24 Dredging as part of seabed preparation for individual gravity base foundations associated with the HVAC substation 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).

6.5.1.25 Offshore HVAC booster stations installed on piled jacket foundations may require drilling to assist with pin pile penetration. Drilling of jacket foundations results in the release of relatively smaller overall volumes of relatively finer sediment, at lower rates, than similar potential impacts for bed preparation via dredging for gravity base foundations.

6.5.1.26 The impact to the subtidal qualifying Annex I habitats of the North Norfolk Sandbanks and Saturn Reef SCI from cable installation, including sandwave clearance and HVAC sub-station installation, is predicted to occur at discrete locations within the SCI 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.

6.5.1.27 In relation to the fauna supported by SCI 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, 2016a).

6.5.1.28 *S. spinulosa*, which is a feature of Annex I reefs of the North Norfolk Sandbanks and Saturn Reef SCI, 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).

6.5.1.29 The PEIR Volume 2, Chapter 2: Benthic Ecology assesses the benthic ecology VER habitats which are representative of the Annex I habitats of the North Norfolk Sandbanks and Saturn Reef SCI as being of low vulnerability, high to immediate recoverability and of regional to international importance with respect to potential impacts from temporary increases in suspended sediments and smothering when considering the maximum design scenarios (Table 5.1). The sensitivity of these qualifying habitat features is therefore considered to be low. The impact on these features is of limited spatial extent, temporary and reversible and therefore of low magnitude.

6.5.1.30 With respect to the Conservation Objectives for the SCI, therefore, there is no indication that temporary increases in suspended sediments/smothering will lead to a reduction in environmental quality, natural environmental processes or extent of the Annex I habitat features within the SCI.

6.5.1.31 There is no indication from the assessment of the likely effects of temporary increases in suspended sediments/smothering that there will be any significant changes to the physical structure, biological diversity, community structure or the typical species that are representative of sandbanks which are slightly covered by seawater all the time or reefs.

Conclusion

6.5.1.32 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 SCI identified in Table 6.1, 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. On this basis, at this stage, an adverse effect that would prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI qualifying Annex I habitat features to favourable condition is not predicted.

Accidental pollution

6.5.1.33 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.

6.5.1.34 There is also a risk to subtidal benthic receptors and subsequently the qualifying Annex I features of the North Norfolk Sandbanks and Saturn Reef SCI from water based drilling mud (i.e. bentonite) used as a lubricant during horizontal directional drill (HDD) process of installing the export cable, should this technique be used at landfall. 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, short-term and quickly dispersed in the high-energy conditions of the marine environment. Such activities will also be very distant from North Norfolk Sand Banks and Saturn Reef SCI and this pathway is not considered further here.

6.5.1.35 The total additional number of construction-related vessel round trips to port expected as a result of construction activities over the construction period is up to 3,420. Although many of the larger 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.

6.5.1.36 Throughout the construction period, fuel will need to be stored offshore in up to six tanks for refuelling of crew transfer helicopters. An impact upon Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI would only occur if fuel is accidentally released, however; the historical frequency of pollution events in the southern North Sea is low considering the density of existing marine traffic in the area.

6.5.1.37 Given the designed-in mitigation (see Table 5.5) the likelihood of accidental release is considered to be extremely low. The measures to be included in the CoCP and PEMMP will include:

- designating areas for refuelling;
- only using chemicals included on the approved Cefas list under the Offshore Chemical Regulations 2002; and
- storage of chemicals in secure designated areas in line with appropriate regulations and guidelines and double skinning of any tanks and pipes containing hazardous substances.

6.5.1.38 Adherence to the mitigation outlined in Table 5.5 (i.e. a CoCP) and best working practices will significantly reduce the likelihood of an accidental pollution incident occurring. The likelihood of an accident between vessels and resulting in an accidental spill during the construction period will be further reduced by the Health, Safety and Environmental Management System (HSE MS) which will be developed and implemented by DONG Energy which incorporates the elements of the Active Safety Management System (ASMS), as required by Marine Guidance Note (MGN) 371. This will be particularly focused on ensuring safety of navigation within proximity of the offshore wind farm (see PEIR chapter 7: Traffic and Transport), but will also apply to activities associated with cable installation and HVAC booster station installation occurring within the SCI.

6.5.1.39 Ant potential impact on the subtidal qualifying Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI is predicted to be of a local spatial extent, short term duration, intermittent and reversible. The magnitude is therefore, considered to be negligible.

6.5.1.40 *S. spinulosa* larvae are known to be highly intolerant of some oil dispersants although adult forms have been found to thrive in polluted areas (Jackson and Hiscock, 2008). The recoverability of these communities to contaminants of this nature is likely to be moderate to high as a result of the life history characteristics of the component species (see volume 5, annex 2.1: Benthic Ecology Technical Report). These would facilitate rapid recolonisation of affected areas via larval settlement following a return to ecological baseline conditions and baseline levels of contaminants.

6.5.1.41 Experimental evidence is limited and the assessments described above have been derived from sources that only cover some aspects of the habitats and species, or from general understanding of the habitats or species (www.marlin.ac.uk). However, subtidal sediments in high energy environments such as those represented in this SCI are generally less vulnerable to this type of pollution than low-energy intertidal habitats. The hydrodynamic regime in the offshore parts of Hornsea Three would also lead to high dispersion and breakdown of pollutants, which would be expected to reduce the concentration of contaminants and therefore also the effects on subtidal receptors associated with a severe pollution event (Elliott *et al.*, 1998). 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.

6.5.1.42 The PEIR Volume 2, Chapter 2: Benthic Ecology concluded that any impact on subtidal benthic receptors would be of negligible magnitude because it would be of local spatial extent, short term duration, intermittent and reversible. Furthermore, these receptors are considered to be of moderate vulnerability to these potential effects and have high recoverability. It is therefore appropriate to apply the same conclusion to the subtidal qualifying Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI.

6.5.1.43 With respect to the Conservation Objectives for the SCI, 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 SCI is designated.

<u>Conclusion</u>

6.5.1.44 Provided published guidelines, best working practices and the mitigation measures outlined in Table 5.5 (i.e. implementation of a PEMMP) 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 SCI identified in Table 6.1, in relation to accidental pollution.

6.5.1.45 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

6.5.2 Potential impacts - operation and maintenance

Long term habitat loss

6.5.2.1 It is predicted that there will be some loss of habitat directly under export cables where cable protection is required (PEIR Volume 2, Chapter 2: Benthic Ecology). Additionally, the current search area for the offshore HVAC booster station overlaps with the boundary of the North Norfolk Sandbanks and Saturn Reef SCI (Table 6.1) and should this structure be developed within the SCI there would be some loss of habitat beneath the footprint of this structure.

6.5.2.2 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 SCI it should be assumed that the sites qualifying Annex I habitat features are present across the entire area of the site.

6.5.2.3 The MDS assumes the requirement of cable protection for 10% of the entire cable corridor. In order to assess the maximum design scenario, this assessment assumes that all this 10% would occur within the boundaries of the site, although it is acknowledged that this scenario highly unlikely and over estimates the probable impact on the SCI. Furthermore, it has been assumed that 21 of the 37 crossings detailed in the MDS table will be present within the boundary of the site.

6.5.2.4 There is the potential for an HVAC booster station to be positioned within the boundary of the SCI. In order to assess the maximum design scenario, this assessment has considered the entire HVAC search area that overlaps with the North Norfolk Sandbanks and Saturn Reef SCI as representing potential habitat loss (Figure 6.5).

6.5.2.5 The area of the North Norfolk Sandbanks and Saturn Reef SCI is 3603.41km^2. Based on the assumptions above the potential area of long term habitat loss within the SCI is:

- Cable protection: 726,600m^2 (all 10% occurring in SCI) + 352,800m^2 (21x6x2800) = 1,079,400m^2/1.0794km^2 representing 0.03% of the SCI and subsequently 0.03% of the qualifying Annex I habitat features of the SCI and,
- HVAC Booster station: 21.92km^2 representing 0.61% of the SCI and subsequently 0.61% of the qualifying Annex I habitat features of the SCI. NOTE: this represents the search area for the HVAC booster station, the extent of habitat loss within the SCI will be considerably less than this.

6.5.2.6 The maximum total area of SCI with the potential to be subject to long term habitat loss is 22.99km^2 representing 0.64% of the SCI and subsequently 0.64% of the qualifying Annex I habitat features of the SCI. This is small in the context of the area of the SCI and will be considerably less in real terms considering, should the HVAC booster station be positioned within the boundary of the SCI, the actual footprint would not be equal to the entire search area assessed here and additionally, it is highly unlikely that all cable protection predicted would be situated within the SCI.

6.5.2.7 The impact of long term habitat loss within the North Norfolk Sandbanks and Saturn Reef SCI is predicted to be localised to discrete sections of the Hornsea Three offshore cable corridor, and the location of the HVAC booster station. The features of the site are deemed to be of high vulnerability and there is no potential for the recoverability of the affected habitats for the lifetime of the project.

6.5.2.8 With respect to the Conservation Objectives for the SCI, there is no indication that 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 less than 0.64% of the Annex I habitat features within the SCI. In practice it is considered that the area of habitat affected will be significantly less than this and 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.

6.5.2.9 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 SCI, 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

6.5.2.10 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 SCI identified in Table 6.1, in relation to long term habitat loss.

6.5.2.11 There is no indication that localised long term habitat would adversely affect the ability for the Conservation Objectives of this SCI 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 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

Colonisation of hard structures and INNS

6.5.2.12 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 changes in biodiversity. These structures have the potential to act as artificial reef, but could facilitate the spread of invasive and non-native species.

6.5.2.13 The installation of new hard substrate habitat (HVAC foundations, cable protection and scour protection) together with trips to port by operational and maintenance vessels will contribute to the risk of introduction or spread of INNS in ballast water. Designed-in measures including a biosecurity plan, a PEMMP and vessels complying with the International Maritime Organization (IMO) ballast water management guidelines will ensure that the risk of potential introduction and spread of INNS will be minimised (Table 5.5).

6.5.2.14 Hard substrate, with the exception of cobbles and boulders, is rare within the Hornsea Three benthic ecology study area. Any increase in hard substrate, and associated increases in biodiversity, will potentially affect the Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI if it facilitates colonisation of INNS requiring such substrate for settlement in areas previously more dominated by fine sediments; for example, the slipper limpet (*Crepidula fornicata*) attaches to stones on soft substrates (MarLIN, 2017).

6.5.2.15 Habitats along the Hornsea Three offshore cable corridor, including within North Norfolk Sandbanks and Saturn Reef SCI, are likely to be subjected to a lower risk of INNS introduction than the array area as only export cables and potentially the foundations associated with an HVAC booster station will be present and the cable will be buried for the most part.

6.5.2.16 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.

6.5.2.17 The MDS assumes the requirement of cable protection for 10% of the entire cable corridor. In order to assess the maximum design scenario this assessment assumes that all this 10% would occur within the boundary of the SCI, although it is acknowledged that this scenario is highly unlikely and over-estimates the probable impact. Furthermore, it has been assumed that 21 of the 37 crossings detailed in the MDS table will be present within the boundary of the SCI.

6.5.2.18 The area of the North Norfolk Sandbanks and Saturn Reef SCI is 3,603.41 km^2. Based on the assumptions above the potential area of habitat creation within the SCI is:

- Cable protection: 726,600 m^2 (all 10% occurring in SCI) + 352,800 m^2 (21 x 6 x 2,800) = 1,079,400 m^2 / 1.0794 km^2 representing 0.03% of the SCI; and
- HVAC booster station: 21.92km^2 representing 0.61% of the SCI (note: this represents the search area for the HVAC booster station, the extent of habitat creation will be considerably less than this).

6.5.2.19 The maximum total area of potential habitat creation within the SCI is 22.99km^2 representing 0.64% of the SCI. This is small in the context of the area of the SCI and will be considerably less in real terms considering, should the HVAC booster station be positioned within the boundary of the SCI, the actual footprint would not be equal to the entire search area assessed here and additionally, it is highly unlikely that all cable protection predicted would be situated within the SCI.

6.5.2.20 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). A study by Kerckhof *et al.* (2011) of colonisation of Belgian offshore wind farm structures found that creating a new intertidal habitat in an offshore environment resulted in non-indigenous species constituting a major part (approximately one third) of the intertidal colonists.

6.5.2.21 All of the non-indigenous species observed, however, were already known to occur in the southern North Sea. These included the barnacles *Elminius modestus* and *Balanus perforatus*, the marine splash midge *Telmatogeton japonicas*, and the amphipod *Jassa marmorata*. Only one non-native species, the invasive American slipper limpet Crepidula fornicata, was found subtidally on the turbine columns (Kerckhof *et al.*, 2011). *C. fornicata* can be a threat to muddy, mixed and clean sandy biotopes (Blanchard, 1997; De Montaudouin & Sauriau, 1999) though the availability of hard structures and particularly sediments with high gravel or shell content can support high densities of this gastropod (Bohn *et al.*, 2015).

6.5.2.22 The carpet sea squirt *Didemnum vexillum*, believed to be native to Japan, was recorded in Holyhead in 2008 and was the first known occurrence of this organism in the United Kingdom (UK). The limited evidence of the distribution of this species within the in the UK suggests that *D. vexillum* is currently restricted to artificial surfaces in the UK. Mobile sands are unsuitable for growth, however, *D. vexillum* may have the potential to colonise and dominate offshore gravel habitats.

6.5.2.23 Non-indigenous species currently co-exist with indigenous species in the region, as demonstrated by the fact that *C. fornicata* was identified within the Hornsea Three benthic ecology study area. Post-construction monitoring of the monopile structures at the OWEZ using video footage and samples collected by divers recorded colonisation by introduced/non-indigenous species including Japanese oyster *Crassostrea gigas*, slipper limpet and the Titan acorn barnacle *Megabalanus coccopoma* (Lindeboom *et al.*, 2011).

6.5.2.24 Post construction monitoring of the Barrow offshore wind farm monopiles found no evidence of invasive or non-native species and similarly, studies of the Kentish Flats monopiles identified only *C. fornicata* (Cefas, 2009). The non-indigenous Japanese skeleton shrimp *Caprella mutica* was recorded at the Horns Rev offshore wind farm and despite its ability to rapidly colonise the turbine structures only negligible effects were observed on native communities and these resulted from an increase in local biodiversity and food availability rather than from negative effects (e.g. competition and predation) associated with the non-indigenous species (Bioconsult, 2006). The capacity for introduced hard substrate to facilitate the introduction and spread of non-indigenous species (e.g. via stepping stone effects) could potentially affect subtidal benthic habitats.

6.5.2.25 Any impact on the qualifying features in the North Norfolk Sandbanks and Saturn Reef SCI 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 (25 years - lifetime of Hornsea Three), continuous and irreversible. However, the sandbank and reefs habitats of the North Norfolk sandbanks and Saturn Reef SCI are considered to have low vulnerability to this potential impact.

6.5.2.26 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 SCI due to the colonisation of hard structures introduced into the SCI 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.

<u>Conclusion</u>

6.5.2.27 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 SCI identified in Table 6.1 in relation to the colonisation of hard structures by INNS.

6.5.2.28 There is no indication that the colonisation of hard structures by INNS would adversely affect the ability for the Conservation Objectives of this SCI 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

Changes in physical processes

6.5.2.29 PEIR chapter 1: Marine Processes assesses predicted changes to waves (both in isolation and cumulatively), scour and tidal currents. It concludes that the presence of foundation structures (for the HVAC booster station) and associated scour protection along with cable protection within the SCI may introduce changes to the local hydrodynamic and wave regime, resulting in changes to the sediment transport pathways and associated effects on benthic ecology. In addition the presence of wind turbine foundations within the array also has the potential to affect the wave regime which could lead to potential (remote) impacts, including potentially on Annex I sandbanks which are slightly covered by seawater all the time found within the North Norfolk Sandbanks and Saturn Reef SCI.

6.5.2.30 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 chapter 1: Marine Processes) which would not affect Annex I habitat interest features at North Norfolk Sandbanks and Saturn Reef SCI. 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.

6.5.2.31 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.

6.5.2.32 With respect to offshore sandbanks 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 approximately 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 ~2.5% in the vicinity of sandbanks closer inshore (e.g. Ower Bank; see chapter 1: Marine Processes). It is predicted that a reduction in wave height described above would potentially impact upon the sediment transport occurring at the crest of the sandbanks and would not impact on the troughs where the benthic ecology is of higher value.

6.5.2.33 By definition, 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). Site features are of international importance and are therefore considered to be of medium sensitivity. This reflects the assessment of the Annex I sandbank features of the North Norfolk Sandbanks and Saturn Reef SCI in chapter 1: Marine Processes, for changes to the wave regime impact.

6.5.2.34 *S. spinulosa* is dependent upon a supply of suspended sediments for tube-building and changes to the hydrodynamic regime may also affect sediment and/or *S. spinulosa* larval supply and so this habitat is also considered to be of medium sensitivity to this impact.

6.5.2.35 PEIR Volume 2, Chapter 2: Benthic Ecology assesses the potential effect of changes to physical processes. It concludes that the predicted changes to flow rate are small and below the MarLIN benchmark levels used to assess the sensitivity of the receptors. Although effects may be observed they are likely to be more subtle than those described above. Benthic species in the area are tolerant to a certain degree of instability, as well as fluctuating levels of suspended sediments and variable sediment deposition rates, arising from scour and/or small changes in the local wave and tide regime and a significant impact was not predicted on any subtidal VERs (including features of the SCI).

6.5.2.36 The predicted impacts of changes in physical processes along the Hornsea Three offshore cable corridor and HVAC booster station are predicted to be of long term duration, continuous and irreversible for the lifetime of Hornsea Three, but of highly localised extent. Whilst SCI features will be affected directly, the magnitude of any impact is considered to be negligible. 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 SCI. Nor is there any indication that the physical structure, diversity, community structure or typical species of these features would be significantly changed.

Conclusion

6.5.2.37 There is no indication that changes in physical processes would adversely affect the ability for the Conservation Objectives of this SCI 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

Temporary seabed disturbance

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

6.5.2.39 The impacts associated with these operations are likely to be similar in nature to those associated with the construction phase although of reduced magnitude.

6.5.2.40 Only works in the Hornsea Three offshore cable corridor, within the North Norfolk Sand and Saturn Reef SCI are of relevance to the Draft Report to Inform Appropriate Assessment. Subtidal cable reburial/repair works (if and when necessary) will affect habitats in the immediate vicinity of cable reburial operations. As outlined in volume 1, chapter 3: Project Description, it is expected that, on average, the subsea cables will require up to two visits per year for the first three years, reducing to yearly thereafter for preventative maintenance including routine inspections to ensure the cable is buried to an adequate depth. Additional visits may be required by specialised vessels should remedial measures be required, although it is not possible to accurately quantify the area potentially affected.

6.5.2.41 The temporary disturbance to habitats along the Hornsea Three offshore cable corridor as a result of cable reburial (if any) will be of a much smaller magnitude than that described for the construction phase.

6.5.2.42 Temporary seabed disturbance will be avoided where possible to minimise any direct impacts on Annex I habitat features of the North Norfolk sandbanks and Saturn Reef SCI (Table 5.5). Pre-construction surveys are to be undertaken along the Hornsea Three offshore cable corridor to identify these discrete benthic habitats of conservation importance, and appropriate mitigation will be discussed and agreed with statutory consultees to avoid direct impacts on these features (Table 5.5).

6.5.2.43 *S. spinulosa* have typically low to intermediate intolerance to physical disturbance. However, recovery is likely to be high as the species are highly mobile, tolerant of sediment movement and would accompany the influx/re-settlement of disturbed material (Budd, 2008a; Rayment, 2008a; Rayment 2008b). As such, nothing more than minor localised declines in species richness are predicted as a result of maintenance jack-up and cable re-burial operations. In addition, the frequency of maintenance jack-up operations (i.e. approximately six over the lifetime of a turbine) will allow for the recovery of benthic communities between these events.

6.5.2.44 The impact on qualifying Annex I habitats of the North Norfolk Sandbanks and Saturn Reef SCI are predicted to be of local spatial extent, short term duration, intermittent and reversible and the overall potential impact is considered to be negligible.

Conclusion

6.5.2.45 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 SCI identified in Table 6.1 in relation to temporary seabed disturbance.

6.5.2.46 There is no indication that temporary seabed disturbance would adversely affect the ability for the Conservation Objectives of this SCI 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

Accidental pollution

6.5.2.47 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.

6.5.2.48 The magnitude of the impact is entirely dependent on the nature of the pollution incident but the SEA carried out by DECC (2011c) 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.

6.5.2.49 A potential for accidental spills arises as a result of the 2,382 round trips to port by maintenance and operational vessels and up to 25,234 round trips by helicopter over the 25 year design life of the project (Table 5.1). However, as the majority of these vessels will be crew/supply vessels and helicopters, these will be typically small and will therefore be carrying only limited amounts of potential contaminants. 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.

6.5.2.50 Throughout operation there will be the requirement to store fuel offshore for the purposes of refuelling crew transfer vessels and/or helicopters, this storage will be on up to three of the offshore accommodation platform barges. An impact upon benthic ecology receptors and subsequently the qualifying Annex I habitat features of the North Norfolk sandbanks and Saturn Reef SCI, would only be realised if an incident occurs where the fuel is accidentally released.

6.5.2.51 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 5.5) 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 DONG Energy which incorporates the elements of the ASMS, as required by MGN 371 (see chapter 7: Shipping and Navigation).

6.5.2.52 Annex I habitat features of the SCI are identified as having intermediate to high intolerance to synthetic compound and hydrocarbon contamination, with localised declines in species richness likely as a result of this type of contamination. The recoverability of these communities is however likely to be moderate to high due to the life history characteristics of the component species, although this is based on limited experimental data (see Hornsea Three Benthic Ecology Technical Report). Recoverability is likely to be assisted by the hydrodynamic regime in the offshore parts of Hornsea Three which would lead to rapid dispersion of pollutants, reducing the probability of a severe pollution event (Elliott *et al.*, 1998).

6.5.2.53 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 SCI, is predicted to be of local to regional spatial extent, short term duration, intermittent and reversible. It is predicted that the impact would affect SCI features directly and/or indirectly, but that the likelihood of an accidental pollution incident occurring is very small and the potential of an adverse impact is therefore considered to be negligible.

<u>Conclusion</u>

6.5.2.54 Provided published guidelines, best working practices and the mitigation measures outlined in Table 5.5 (i.e. implementation of a PEMMP) 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 SCI identified in Table 6.1, in relation to accidental pollution during operation and maintenance.

6.5.2.55 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

6.6 In-combination assessment methodology

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

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 Draft Report to Inform Appropriate Assessment were initially identified from the results of a screening exercise undertaken for the PEIR (see 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 Draft Report to Inform Appropriate Assessment upon data confidence, effect-receptor pathways and the spatial/temporal scales involved. Section 5.4 details the approach to the in-combination assessment.

6.6.1.2 The specific projects scoped into this in-combination assessment and the Tiers into which these have been allocated, are outlined in Table 6.5 and shown in Figure 6.5. 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.

6.6.2 Maximum design scenario

6.6.2.1 The in-combination impacts presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (PEIR 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.

6.6.3 In-combination screening conclusions

6.6.3.1 The only European site with offshore qualifying Annex I habitats for which potential impact pathways arising from activities associated with Hornsea Three in-combination with other plans/projects have been identified is the North Norfolk Sandbanks and Saturn Reef SCI.

6.6.3.2 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 qualifying Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI.

6.6.3.3 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.

6.6.3.4 There are no Tier 2 or Tier 3 projects/plans screened into the in-combination assessment.

6.6.3.5 The Tier 1 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 SCI are described in Table 6.5 and shown in Figure 6.5.

6.6.3.6 A number of impacts set out in Table 6.2 have not been considered in the in-combination assessment due to the highly localised nature of some of the impacts and/or where the potential significance of impact has been assessed as negligible for Hornsea Three offshore wind farm alone. Details are provided below.

6.6.3.7 Accidental pollution events during construction/decommissioning and operation and maintenance along with temporary seabed disturbance during operation and maintenance phase have been screened out of the in-combination assessment due to negligible potential impact alone.

6.6.3.8 The potential impacts of long-term habitat loss, colonisation of hard structures and changes in physical processes during operation and maintenance phase have been screened out as there have been no in-combination impact pathways identified with the plans and projects screened in (Table 6.5) due to the fact that all the plans and projects screened in are aggregate sites and do not have a project design that would result in an adverse in-combination effect alongside Hornsea Three.

Table 6.5: List of other projects and plans with potential for in-combination effects on the North Norfolk Sandbanks and Saturn Reef SCI.

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	Distance from North Norfolk Sandbanks and Saturn Reef SCI	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 SCI.	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
				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 sandbank or reef habitat.	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 PEIR 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. Therefore, maximum additive effects all plans/projects occurring within the North Norfolk Sandbanks and Saturn Reef SCI 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 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
				Humber 5 - 483	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	2 km	0 km	Yes
				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
				Humber 7 - 491	Operational (with on-going effects)	Licensed and application aggregate extraction area	Operational until 2050	0 km	3 km	Yes
	Operation	Cumulative long term loss of Annex I sandbank or reef habitat through presence of offshore wind farm foundations and related 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 long term habitat loss that overlap with the North Norfolk Sandbanks and Saturn Reef SCI.	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	No
				Humber 5 - 483	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	2 km	0 km	No

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	Distance from North Norfolk Sandbanks and Saturn Reef SCI	Screened in for in-combination assessment
		Alteration of seabed habitats arising from effects on physical processes, wave and tidal regimes resulting in potential effects on Annex I sandbank or reef habitat.	Maximum additive effects of all plans/projects involving the introduction of permanent structures either occurring within the North Norfolk Sandbanks and Saturn Reef SCI or 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 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	No
				Humber 5 - 483	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	2 km	0 km	No
				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	No
				Humber 7 - 491	Operational (with on-going effects)	Licensed and application aggregate extraction area	Operational until 2050	0 km	3 km	No
		In-combination introduction of subtidal hard substrates and associated colonisation.	Maximum additive effects calculated for all plans/projects that may contribute to the introduction of subtidal hard substrate that overlap with the North Norfolk Sandbanks and Saturn Reef SCI.	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	No
				Humber 5 - 483	Application	Licensed and application aggregate extraction area	Application for operation sought up to 31 December 2029	2 km	0 km	No

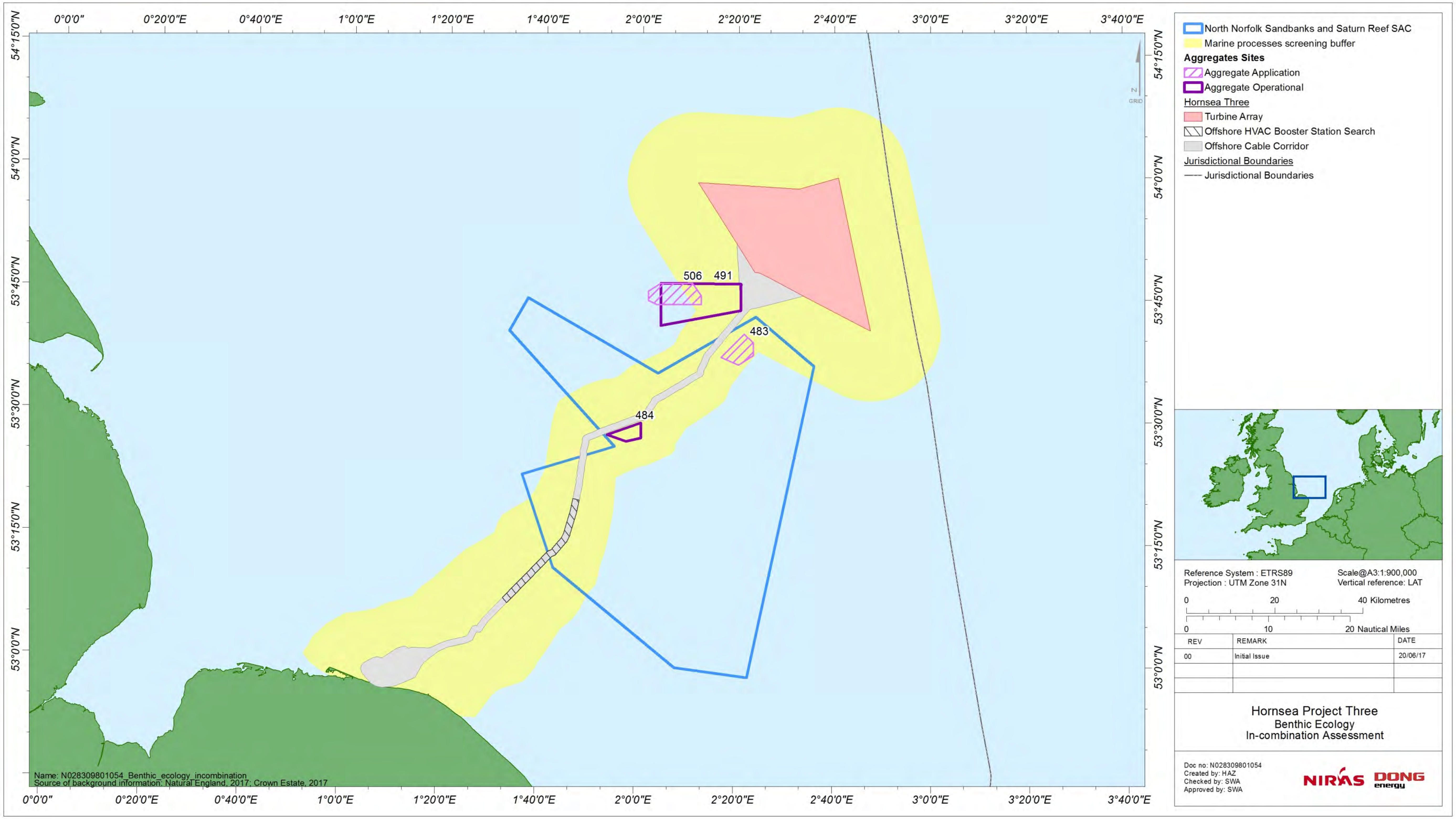

Figure 6.5: Offshore project/plans/activities screened into the in-combination assessment.

6.7 Assessment of potential adverse effect on site integrity in-combination with other plans and projects

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

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

6.7.2 Construction/decommissioning

Temporary habitat loss/disturbance

6.7.2.1 There is the potential for temporary habitat loss as a result of construction activities associated with Hornsea Three in-combination with aggregate extraction activities (see Figure 6.5).

6.7.2.2 All plans/projects/activities screened into the in-combination assessment of temporary habitat loss/disturbance are on-going licensed and application aggregate extraction areas.

6.7.2.3 The predicted temporary habitat loss/disturbance from each of the plans/projects/activities is presented in Table 6.6 together with a breakdown of the sources of this data from the relevant Environmental Statements and any assumptions made where necessary information was not presented in these Environmental Statements. Table 6.6 shows that for all projects/plans/activities in the assessment, the in-combination temporary habitat loss/disturbance is estimated at 8.61 km^2 representing 0.24% of the SCI and subsequently 0.24% of the qualifying Annex I habitat features of the North Norfolk Sandbanks and Saturn reef SCI.

Table 6.6: In-combination temporary habitat loss for Hornsea Three in-combination with other plans/projects/activities.

Project	Total predicted temporary habitat loss (km^2)	Source
Aggregate Application areas	2.82 km^2	10% of total application areas of 28.24 km^2.
Aggregate Licenced areas	1.72 km^2	10% of total licenced areas of 17.20 km^2.
Hornsea Three	4.07 km^2	Installation of export cables

6.7.2.4 However, it is important to note that temporary loss or disturbance of Annex I sandbank or reef habitat will be avoided wherever possible during construction and it is equally assumed that other projects will seek to avoid temporary loss/disturbance of Annex I sandbank or reef habitat wherever possible since these features are subject to strong regulatory protection.

6.7.2.5 The assumption that an average of 10% of the total licensed areas will be dredged at any one time is based on annual reports produced by The Crown Estate for the Humber region which state that recent dredging has taken place within 5 to 10% of the total licensed area each year; in 2012, 9.9% of the total licensed area was dredged (Crown Estate, 2012). The estimate of temporary habitat loss resulting from aggregate extraction activities is also likely to be an over-estimation as only a proportion of the active licence areas are dredged at any one time allowing for recovery between dredging events.

6.7.2.6 The impact of temporary habitat loss in-combination with other plans and projects is predicted to be of local spatial extent, medium term duration, intermittent and reversible but with a very small amount of the loss described occurring at any one time. It is predicted that the impact, if occurring, would affect the SCI features directly. The magnitude of the in-combination impact is considered to be negligible.

6.7.2.7 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).

6.7.2.8 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).

6.7.2.9 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. As such, the vulnerability of habitats is considered to be low to high, but with high recoverability with most recovery occurring within months and full recovery within five years.

6.7.2.10 Annex I sandbank habitat is deemed to be of low vulnerability, high recoverability and of international value. Annex I reef habitat is deemed to be of medium to high vulnerability, high recoverability and international value. Although *S. spinulosa* is likely to recover quickly, the associated high biodiversity may take longer to recover and, as such, the sensitivity of this habitat is considered to be high.

Conclusion

6.7.2.11 Significant impacts are not anticipated to arise as a result of Hornsea Three in-combination with other plans and projects identified in Table 6.5 on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI, 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.

6.7.2.12 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats to favourable condition is not predicted.

Temporary increases in suspended sediment

6.7.2.13 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.

6.7.2.14 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.

6.7.2.15 The licensed aggregate extraction areas 483 and 484, lie 0 km and 2 km from the Hornsea Three cable corridor respectively and overlap with the North Norfolk Sandbanks and Saturn Reef SCI. Aggregate extraction areas 506 and 491 are is 8km and 0 km from the Hornsea Three offshore cable corridor, and 8.5 km and 3 km from the boundary of the North Norfolk Sandbanks and Saturn Reef SCI respectively (see Table 6.5 and Figure 6.5).

6.7.2.16 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 (PEIR, chapter 1: Marine Processes).

6.7.2.17 Plume dispersion modelling results for Application 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, 2013b). 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, 2013b). 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 (PEIR chapter 1: Marine Processes).

6.7.2.18 The turbid plume arising from the proposed dredging activities at Application Areas 506 and 491 (see Figure 6.5) 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).

6.7.2.19 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 (PEIR 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 (PEIR chapter 1: Marine Processes).

6.7.2.20 The impact of increased SSC and sediment deposition on Annex I sandbank and reef features of the North Norfolk Sandbanks and Saturn Reef SCI from dredging at aggregation extraction areas 483, 484, 506 and 491, 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 short term and intermittent duration, and reversible to baseline conditions following cessation of activities.

6.7.2.21 Annex I sandbank and reef are considered to be of low vulnerability, high recoverability and of regional importance. The sensitivity of these features is therefore considered to be low.

Conclusion

6.7.2.22 Significant impacts are not anticipated to arise as a result of Hornsea Three in-combination with other plans and projects identified in Table 6.5 on Annex I habitat features of the North Norfolk Sandbanks and Saturn Reef SCI, in relation to temporary increases in suspended sediment. 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.

6.7.2.23 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. On this basis, at this stage, an adverse effect that will prevent the return of the North Norfolk Sandbanks and Saturn Reef SCI Annex I habitats (sandbanks which are slightly covered by seawater all the time and reef) to favourable condition is not predicted.

6.8 Summary

6.8.1.1 The screening process indicated that LSE on the interest features of the North Norfolk Sandbanks and Saturn Reef SCI could not be discounted and so a systematic assessment of the potential for an adverse effect on the integrity of this site 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 site's 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 restoration of favourable condition for the Annex I habitats for which the North Norfolk Sandbanks and Saturn Reef SCI is designated, including:

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

6.8.1.4 On this basis, there is no indication of an adverse effect on integrity on the North Norfolk Sandbanks and Saturn Reef SCI.

6.8.1.5 These conclusions are summarised in Table 6.7 below.

Table 6.7: Summary of conclusions of Adverse Effects on Integrity 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
North Norfolk Sandbanks and Saturn Reef SCI	• Sandbanks which are slightly covered by seawater all the time; and • Reefs.	Construction/ Decommissioning	• Temporary habitat loss/disturbance; • Temporary increases in suspended; and sediments/smothering.	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
			• Accidental pollution.		N/A
		Operation/ Maintenance	• Long-term habitat loss; • Colonisation of hard structures; • Changes in physical processes; • Temporary seabed disturbance; and • Accidental pollution.	No adverse effect on site integrity predicted	N/A

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

7.1 Introduction

7.1.1.1 The screening exercise (Stage 1 of the HRA process) and subsequent evaluation in Section 4.4, identified potential for LSEs on marine mammal features of the sites listed in Table 7.1 and shown in Figure 7.1.

7.2 Conservation Objectives

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

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.

7.2.1.2 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 Southern North Sea cSAC to meet the Conservation Objectives and maintain the existing Favourable Conservation Status (FCS) of the species.

7.2.1.3 The Conservation Objectives specifically for each site and associated marine mammal qualifying feature, screened in for assessment (Table 7.1) are outlined below. Where available the Natural England supplementary advise had be used to refine the Conservation Objectives for each site.

7.2.2 The Wash and North Norfolk Coast SAC:

7.2.2.1 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

7.2.3 Humber Estuary SAC/Ramsar:

7.2.3.1 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 advise 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.

7.2.4 Southern North Sea cSAC:

7.2.4.1 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:

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

7.2.5 Klaverbank SCI Conservation Objectives:

7.2.5.1 Harbour seal and grey seal:

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

7.2.5.2 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).

7.2.6 Doggersbank SCI Conservation Objectives:

7.2.6.1 Maintenance at favourable conservation status of the qualifying species and their natural habitats.

7.2.7 Noordzeekustzone SAC/ Noordzeekustzone II SCI Conservation Objectives:

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

7.3 Potential impacts

7.3.1.1 The potential effects on marine mammal features for each potential impact screened into the assessment (Table 7.1) have been described in the PEIR Volume 2, Chapter 4: Marine Mammals and are summarised below (Table 7.2).

Table 7.1: 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 • 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 • 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 • 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 • 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 • 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 • Increased vessel traffic and collision risk • Accidental pollution events
		Operation	• Increased vessel traffic and collision risk • Accidental pollution events

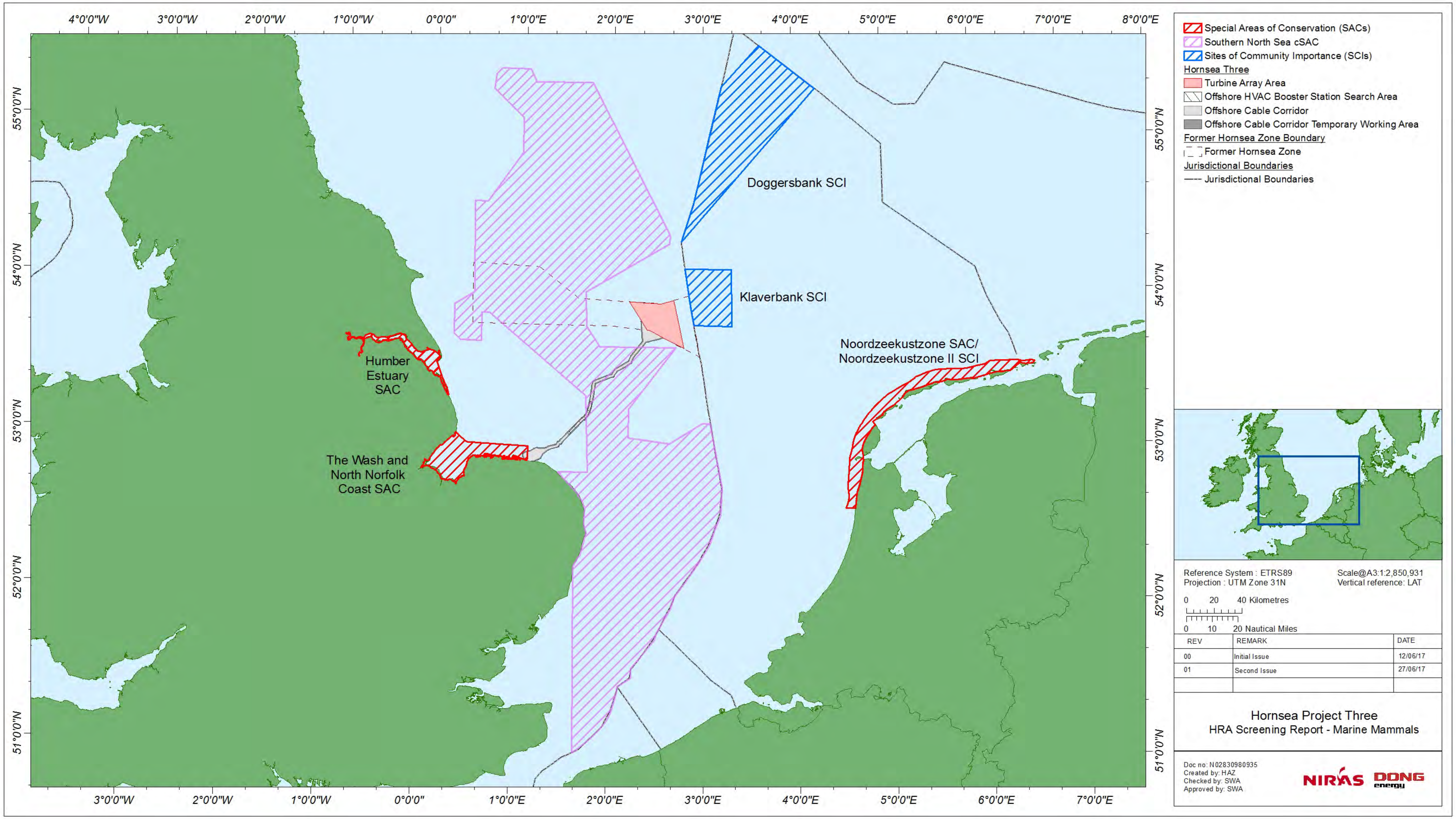

Figure 7.1: European sites designated for Annex II marine mammals identified for further assessment.

Table 7.2: 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 (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.
	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 to those predicted during the construction phase	

7.4 Baseline information

7.4.1.1 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 PEIR volume 5, annex 4.1: Marine Mammal Technical Report.

7.4.2 Study area

7.4.2.1 For the purposes of the marine mammal assessment, the study area (illustrated in Figure 7.2) 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 also includes the former Hornsea Zone plus a 10 km buffer around its perimeter which is the area over which site-specific aerial surveys were undertaken. This area provides a suitable baseline against which to assess potential impacts from Hornsea Three;
- Regional marine mammal study area – this area is represented largely by SCANS (Small Cetaceans Abundance in the North Sea) Block U 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 7.2). 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 7.5 and Figure 7.7).

Management Units

7.4.2.2 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 PEIR volume 5, annex 4.1: Marine Mammal Technical Report provides information on marine mammal populations in a wider geographic frame of reference.

7.4.2.3 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. A recent guidance report prepared by the UK Statutory Nature Conservation Bodies (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).

7.4.2.4 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.

7.4.2.5 All sites screened in for assessment within this Draft Report to Inform Appropriate Assessment are located with the same North Sea MU(s) (see Figure 7.5 and Figure 7.7). 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, Favourable Conservation Status (FCS) of the species will be maintained for a site.

7.4.2.6 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 7.1 in turn.

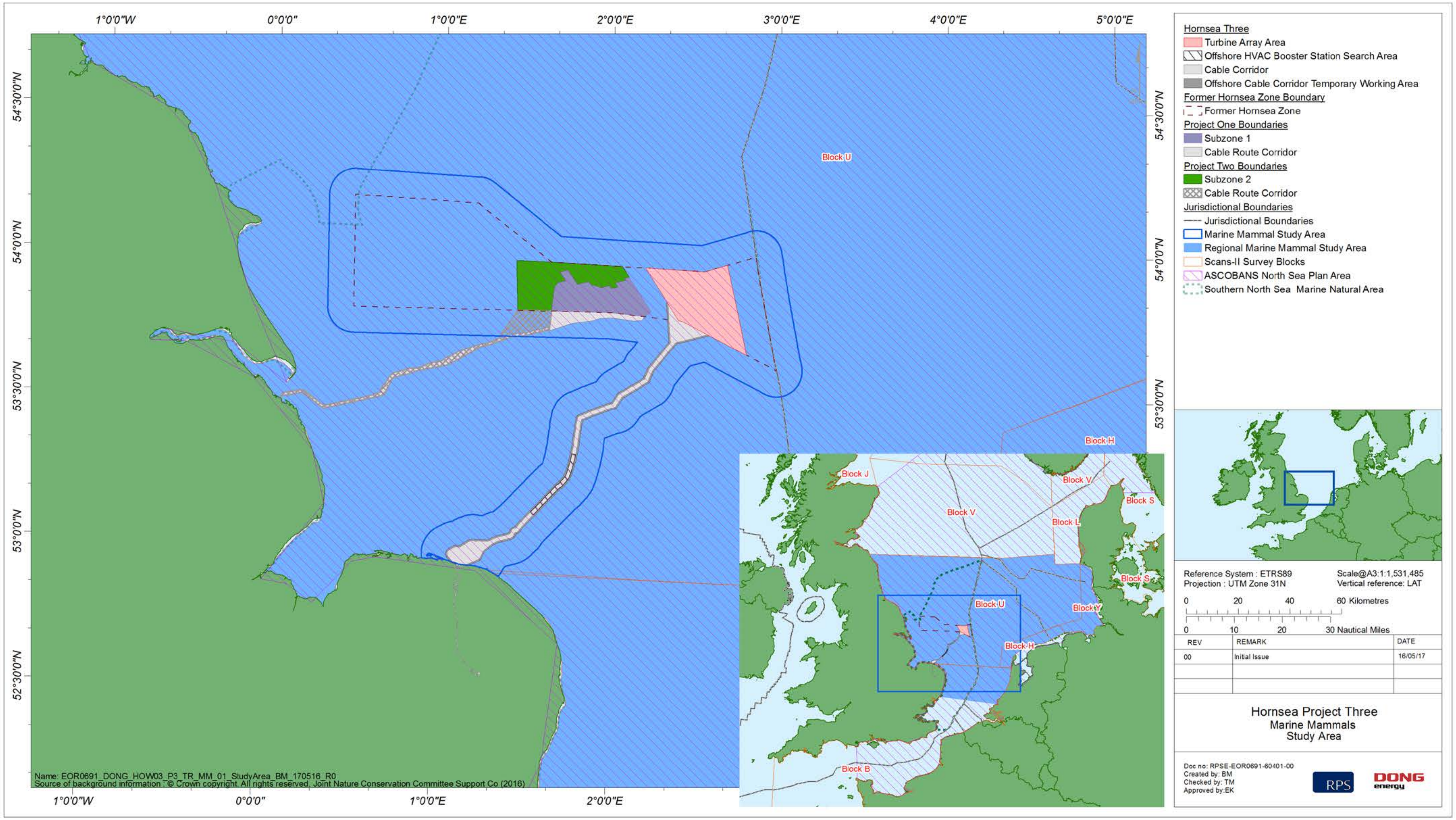

Figure 7.2: Location of the Hornsea Three marine mammal study area (within which is the Hornsea Three array area and offshore cable route corridor and the former Hornsea Zone) and location of the regional marine mammal study area.

7.4.3 Methodology to inform baseline

7.4.3.1 The methodology to inform the baseline was discussed and agreed as part of the Evidence Plan process (draft Evidence Plan, Annex 1 Draft Report to Inform Appropriate Assessment).

7.4.3.2 Data from ongoing aerial surveys of Hornsea Three plus 4 km buffer and any publicly available information that becomes accessible in the required timescale (e.g. JCP data) will be used to inform the baseline for the Environmental Statement and subsequently the final Report to Inform Appropriate Assessment.

7.4.4 Desktop study

7.4.4.1 Information on marine mammals within the regional marine mammal study area was collected through a detailed desktop review of existing studies and datasets (Table 7.3). A full review is provided in PEIR volume 5, annex 4.1: Marine Mammal Technical Report.

7.4.5 Site specific surveys

7.4.5.1 To inform the EIA (PEIR) and HRA (Draft Report to Inform Appropriate Assessment), marine mammal surveys were undertaken, as agreed with the Marine Mammal EWG. A summary of the surveys undertaken to date is outlined in Table 7.4 below.

Data limitations

7.4.5.2 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.

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

7.4.5.4 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 7.3: 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
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	SCOS
Telemetry data for grey and harbour seals tagged along the Norfolk and Lincolnshire coastlines	SMRU	1988 to 2015	Plunkett (2017) (appendix A of PEIR 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 7.4: 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 array area plus 4 km buffer	Monthly aerial surveys of marine mammals (and seabirds) along transects spaced approximately 2.5 km apart over the survey area (Figure 2.3 in annex 4.1: Marine Mammal Technical Report). Surveys commenced in April 2016 and will continue until September 2017. Six months of data were available to inform this PEIR. The full dataset will be available to inform the Environmental Statement. 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. 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 Annex 4.1: Marine Mammal Technical Report)	HiDef	2016 to 2017	PEIR Volume 5, annex 4.1 Marine Mammal Technical Report
Hornsea boat based surveys	Former Hornsea Zone plus 10 km buffer	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 plus 10 km buffer 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 (ESAS) 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	PEIR Volume 5, annex 4.1: Marine Mammal Technical Report

7.4.6 Species accounts

7.4.6.1 Information on the reference populations used for the purposes of the Draft Report to Inform Appropriate Assessment and a summary of the ecology of each Annex II marine mammals feature relevant to this assessment is given in the sections below.

Harbour porpoise

7.4.6.2 According to Reid *et al.*, (2003), harbour porpoise are widespread throughout the temperate waters of the North Atlantic and North Pacific and are the most abundant cetacean in UK waters. In UK water the whole of the coastline of the North Sea is considered an important area for this species.

7.4.6.3 Visual and acoustic sightings data from surveys of the former Hornsea Zone plus 10 km show that harbour porpoise are widely distributed across the Hornsea Three marine mammal study area (Figure 7.2). Similarly, historical sightings data (mainly land-based) from Greater Lincolnshire Nature Partnership (GLNP) confirmed that harbour porpoise is commonly sighted along coastal waters.

7.4.6.4 Harbour porpoise density and abundance derived from boat-based visual and acoustic surveys of the former Hornsea Zone plus 10 km buffer and from aerial surveys of Hornsea Three array plus 4 km buffer are summarised in Table 7.5 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 array area plus 4 km buffer is not of any elevated importance compared to other parts of the former Hornsea Zone plus 10 km buffer. In addition the mean density estimate and spatial patterns in distribution of densities from the more recent aerial surveys is very similar to the boat-based visual density estimate (recognising the limitations of comparing these two datasets: see section 3.2.6 in PEIR volume 5, annex 4.1: Marine Mammal Technical Report).

Table 7.5: 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 plus 10 km buffer			
Visual boat-based	9,276	1.72	15,955
Acoustic boat-based	9,276	2.22	20,593
Hornsea Three plus 4 km buffer			
Visual boat-based	1,230	1.76	1,232
Acoustic boat-based	1,230	2.87	3,530
Aerial video	1,230	1.77	2,177

7.4.6.5 In comparison to the regional marine mammal study area these figures suggest that the Hornsea Three marine mammal study area is of relatively high importance for harbour porpoise since the densities are higher than the average density of 0.598 animals km^{-2} (CV = 0.28) recorded for SCANS block U 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).

7.4.6.6 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 up to the northern tip of Scotland and comprising the ICES areas IV, VIId and Division IIIa. 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). 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.

7.4.6.7 Table 7.6 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 7.6: 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 (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 (Construction) • Increased vessel traffic and collision risk (Construction/Decommissioning/Operation) • Accidental pollution events (Construction/Decommissioning/Operation)

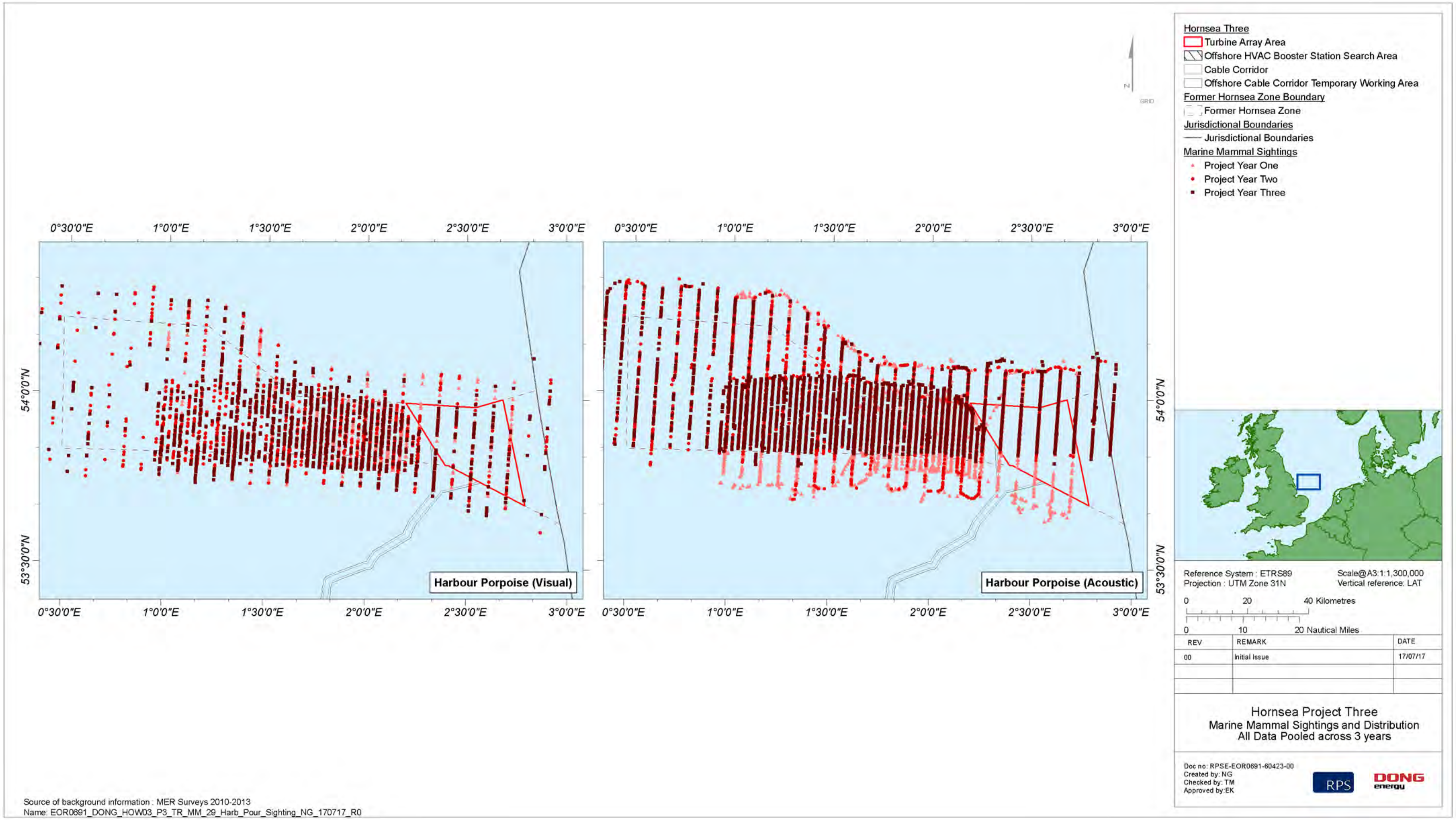

Figure 7.3: Harbour porpoise sighting and distribution. All data pooled across three years of boat-based surveys.

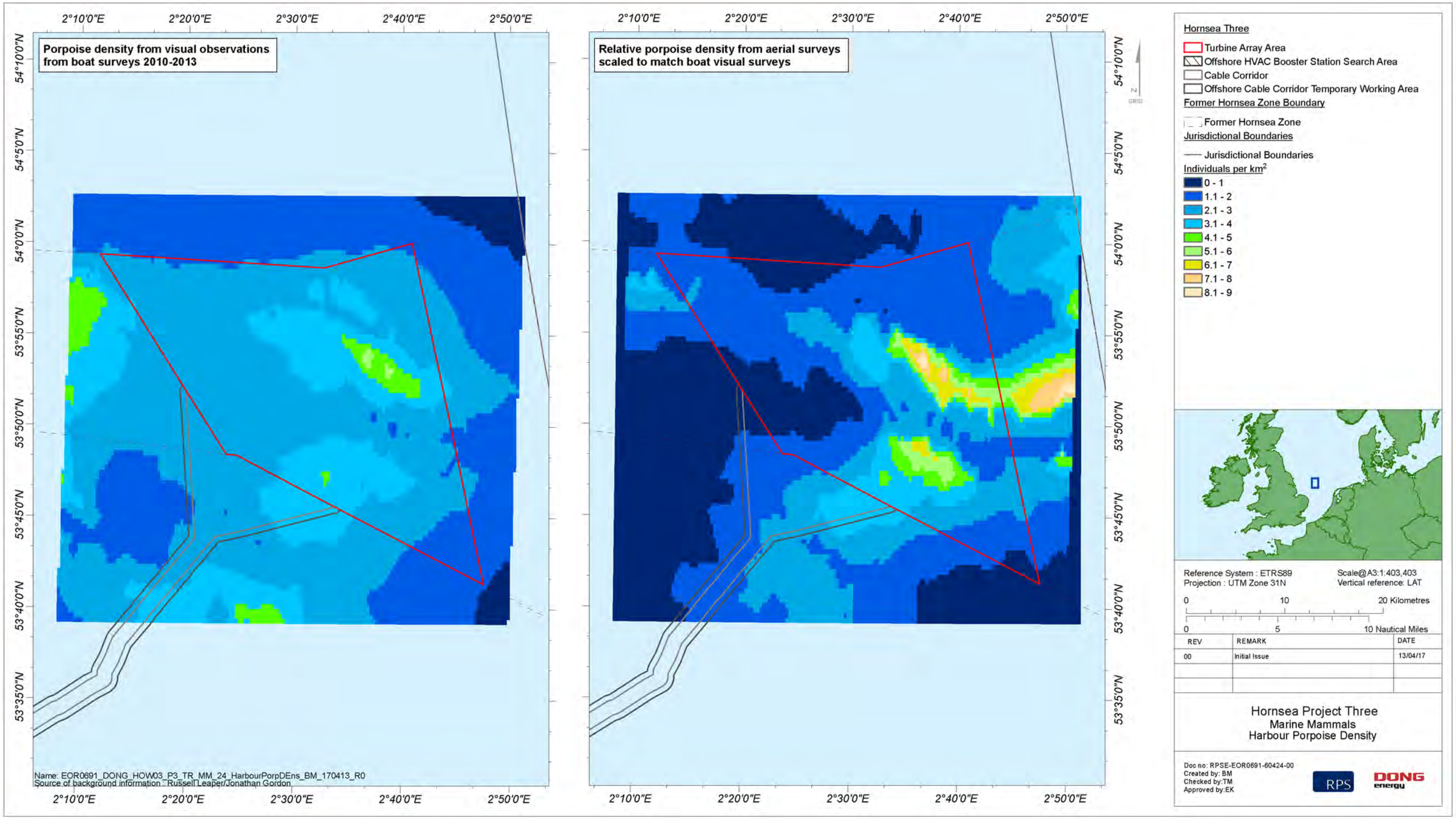

Figure 7.4: Surface density maps for harbour porpoise for Hornsea Three plus 4 km buffer with aerial data scaled to give the same mean density as the boat-based data for comparative purposes.

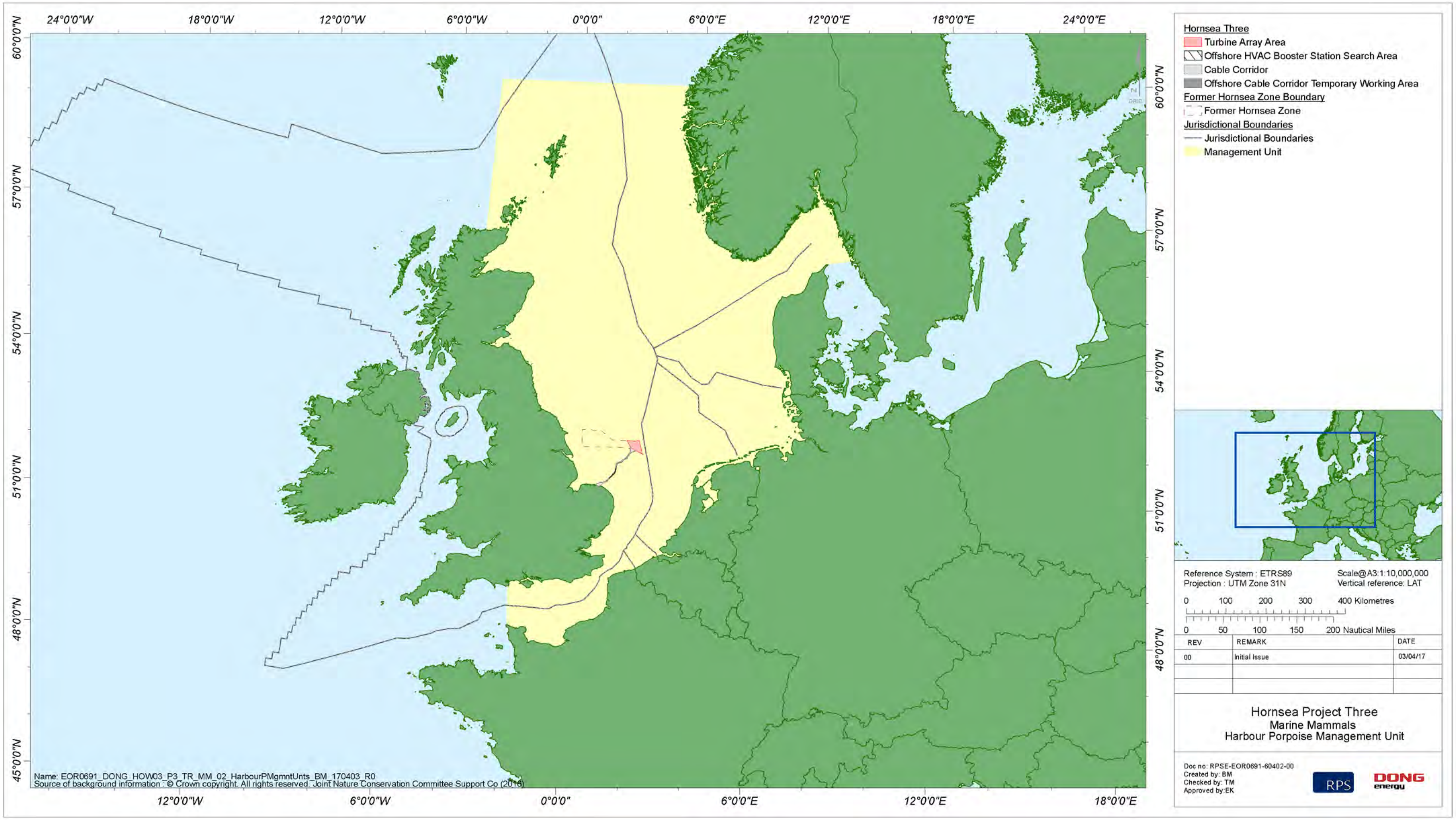

Figure 7.5: Harbour porpoise Management Unit.

Grey Seal

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

7.4.6.9 During boat-based surveys across the former Hornsea zone plus 10 km buffer, a total of 247 grey seal 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 plus 10 km buffer has been calculated as 371.5 individuals.

7.4.6.10 Grey seal at sea usage data provided by SMRU 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 7.6). The average density for the former Hornsea Zone plus 10 km buffer estimated from the SMRU at-sea data was 1.470 animals km^{-2} compared with 0.04 animals km^{-2} estimated using boat-based data from surveys across the former Hornsea Zone plus 10 km buffer.

7.4.6.11 Female grey seal store fat reserves prior to lactation to allow reduced foraging during lactation. Grey seal are therefore be particularly more vulnerable to disturbance when building up fat reserves.

7.4.6.12 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).

7.4.6.13 Grey seal can travel up to 2,100 km on foraging trips, though most are 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 PEIR volume 5, annex 4.1: Marine Mammal Technical Report), and these are considered likely to be foraging animals.

7.4.6.14 Advice from UK SNCBs is that 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 7.7) with combined associated abundance estimate. The abundance estimate for these combined MUs is 18,150 animals.

7.4.6.15 An estimate of the local (Greater Wash) breeding population has also been provided based on the grey seal pup counts within the Greater Wash area (SCOS, 2015) (see section 4.5.5 of PEIR volume 5, annex 4.1: Marine Mammal Technical Report for methodology). The Greater Wash population estimate has been estimated at 6,586 animals from a pup production estimate of 3,360 (SCOS, 2015).

7.4.6.16 Table 7.7 summarises the designated sites within normal 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 assessment of sensitivity of grey seal as a feature of these sites as well as for the draft Report to Inform Appropriate Assessment (DONG Energy, 2017).

Table 7.7: 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) • Changes in prey availability (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) • Changes in prey availability (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) • Changes in prey availability (Construction/Decommissioning/ Operation) • Accidental pollution events (Construction/Decommissioning/ Operation)
Noordzeekustzone SAC/ Noordzeekustzone II SCI	138	• Noordzeekustzone SAC/ Noordzeekustzone II SCI

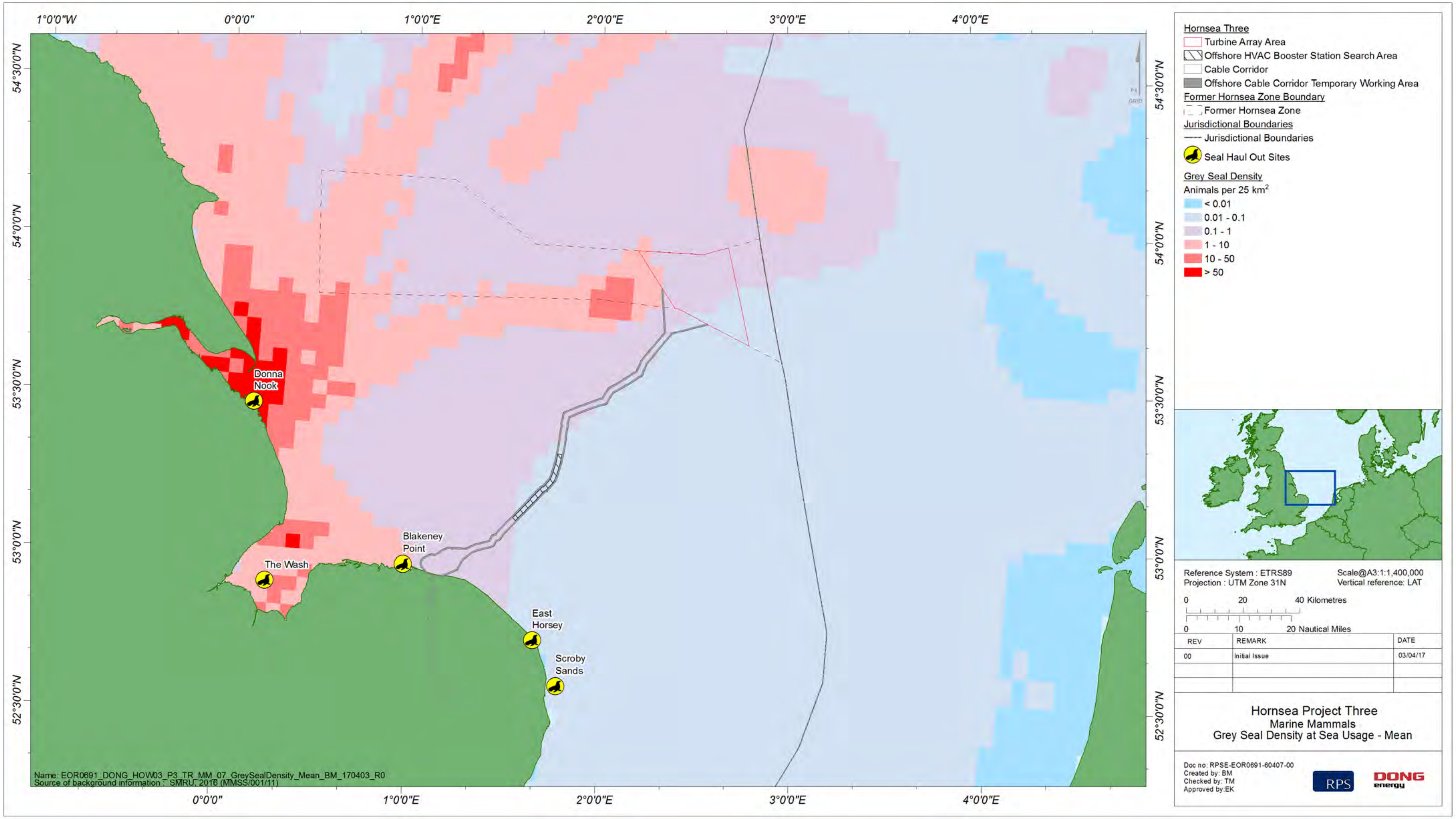

Figure 7.6: Grey seal density At-Sea usage - mean (per 25 km2) for the regional marine mammal study area based on data collected over a 15 year period up to 2015.

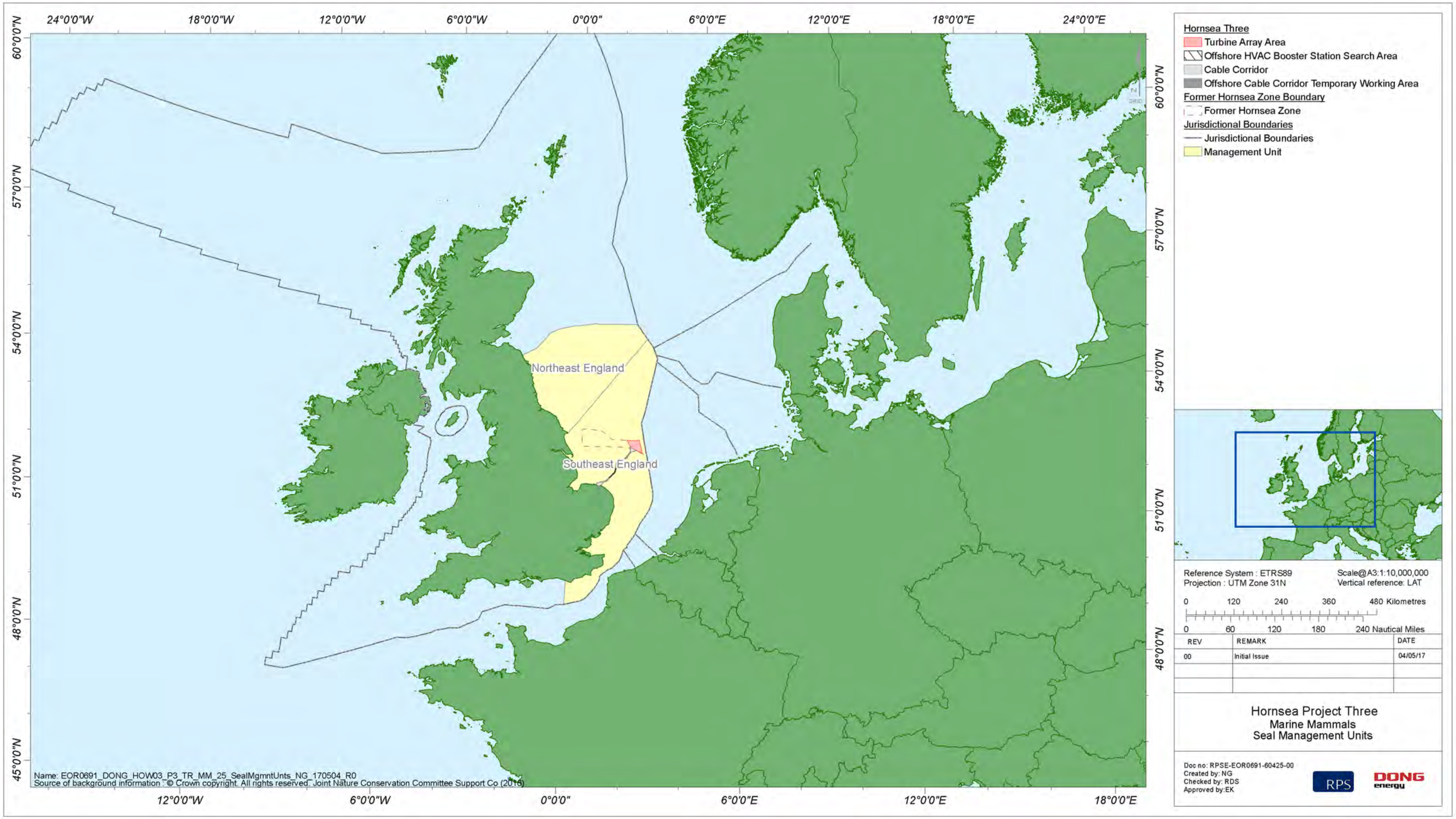

Figure 7.7: Seal Management Units.

Harbour seal

7.4.6.17 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) (Figure 4.31 of PEIR volume 5, annex 4.1: Marine Mammal Technical Report) 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).

7.4.6.18 Boat based surveys of the former Hornsea Zone plus 10 km buffer recorded harbour seal throughout the survey area. In total, 147 harbour seal were recorded. This equated to an approximate absolute density within the former Hornsea Zone plus 10 km buffer of 0.039 animal's km^{-2} and a relative abundance of 167.2 individuals.

7.4.6.19 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 7.8) 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 (Figure 4.5 of PEIR volume 5, annex 4.1: Marine Mammal Technical Report).

7.4.6.20 Using SMRU data, the average modelled surface densities across the former Hornsea zone plus 10 km buffer was calculated at 0.849 animal km^{-2} with a relative 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 (0.0 animals km^{-2}) (Figure 7.8).

7.4.6.21 Harbour seal are likely to be most sensitive to disturbance during the breeding period when females are lactating (Lusseau *et al.*, 2012).

7.4.6.22 Harbour seal 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).

7.4.6.23 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 7.7).

7.4.6.24 Table 7.8 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 Draft Report to Inform Appropriate Assessment.

Table 7.8: 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)

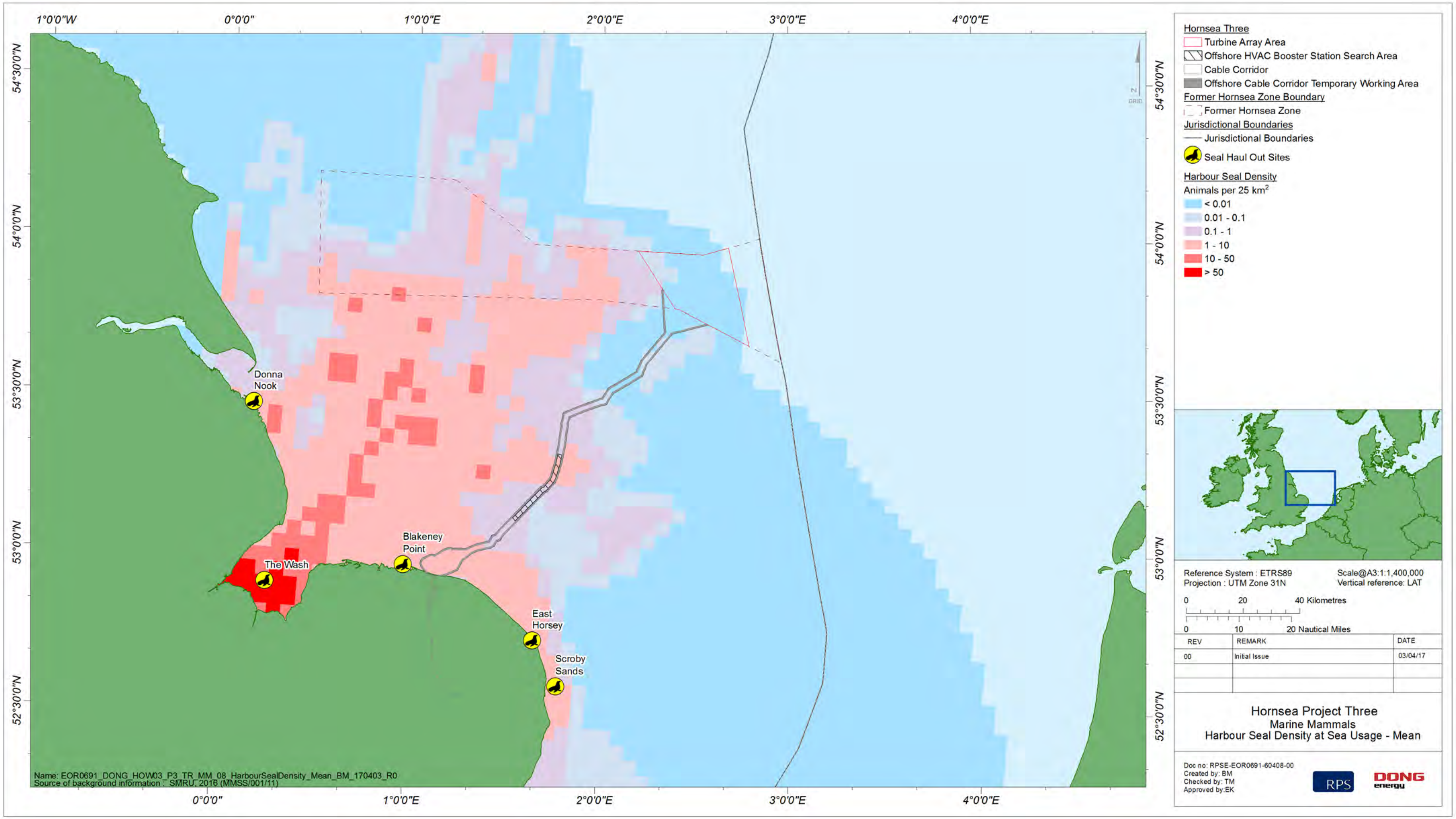

Figure 7.8: Harbour seal density At-Sea usage - mean (per 25 km2) for the regional marine mammal study area based on data collected over a 15 year period up to 2015.

Summary

7.4.6.25 For the purposes of quantifying potential impacts, the following table provides a summary of the mean densities used in the assessment (Table 7.9). 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). For the subsea noise impact assessment, these densities were used to quantify shorter range effects whilst the modelled surface density estimates were used to quantify far-field effects as the latter captures spatial changes in density for each species and were therefore considered to represent a more accurate assessment of potential effects.

Table 7.9: 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	2.87 individuals km^2	Boat-based acoustic surveys of former Hornsea Zone plus 10 km buffer	North Sea (NS)	227,298
Grey seal	1.47 individuals km^2	SMRU at-sea data	South-East England (SEE) and North East England (NEE) combined	18,150
Harbour seal	0.849 individuals km^2	SMRU at-sea data	South-East England (SEE)	3,567

7.5 Assessment of Adverse Effects on Integrity – Alone

7.5.1.1 The potential impacts arising from the construction/decommissioning of Hornsea Three which have been assessed in this Draft Report to Inform Appropriate Assessment are listed in Table 5.2 along with the maximum design scenario against which each construction/decommissioning phase impact has been assessed.

7.5.1.2 The maximum design scenarios identified in Table 5.2 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 (PEIR 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.

7.5.2 Potential impacts – construction/decommissioning

Underwater noise

7.5.2.1 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 (PEIR, Vol 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 within for HRA purposes.

7.5.2.2 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 5.2). 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 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 5.6). 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 (see Table 5.2).

7.5.2.3 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, within the Hornsea Three offshore cable corridor, 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 maximum design scenarios for the spatial and temporal scenarios are summarised in Table 5.2.

7.5.2.4 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 PEIR volume 4, annex 3.1: Subsea Noise Technical Report.

Assessment criteria

7.5.2.5 Marine mammals have a highly developed auditory sense and both cetaceans and pinnipeds vocalise underwater to communicate. Odontocete cetaceans (including dolphin species and 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 and baleen whales, may predominantly occur at certain times of the year associated with breeding or migration.

7.5.2.6 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 volume 4, annex 3.1: Subsea Noise Technical Report). For example, harbour porpoise is of high sensitivity as these animals hear over a large bandwidth of frequencies and their range of perception starts at a much lower sound pressure level than other species. To factor in the sensitivity of species based on their frequency range, different species can be classified into hearing groups (see Table 3.1 in volume 4, annex 3.1: Subsea Noise Technical Report).

7.5.2.7 High levels of underwater sound can potentially have a negative impact on marine mammals ranging from changes in their acoustic communication, displacing them from an area, and in more severe cases causing physical injury or mortality (Richardson *et al*., 1995).

7.5.2.8 The range of effects that could arise from the impact of subsea noise during piling, on marine mammals are described below.

Lethality/injury

7.5.2.9 In general, biological damage as a result of sound is either related to a large pressure change (barotrauma) or to the total quantity of sound energy received by a receptor over a set period. Barotrauma injury can result from exposure to a high intensity sound even if the sound is of short duration, such as an explosion. However, when considering injury due to the energy of an exposure, the time of the exposure becomes important. For example, a continuous source operating at a given sound pressure level has a higher total energy and is therefore more damaging than an intermittent source reaching the same sound pressure level (Southall *et al*., 2007).

7.5.2.10 High levels of noise exposure can cause an instantaneous auditory injury resulting in a Permanent Threshold Shift (PTS) that persists once sound exposure has ceased. In addition, PTS may also result from prolonged exposure at lower levels sufficient to cause a Temporary Threshold Shift (TTS). Although animals are able to recover fully from TTS, particularly as they move away from the sound source, hearing loss may become permanent if hearing does not return to normal after several weeks. Therefore, the distinction between TTS and PTS depends on whether there is complete recovery of the individual's hearing.

7.5.2.11 The relationship between these two thresholds is complex since PTS can either be induced by a single high level noise exposure, or by chronic (longer term) noise exposure at lower levels (Southall *et al*., 2007). The threshold for auditory injury is therefore taken as the levels at which PTS starts to occur, based on the overall noise dose received over time, and is termed the PTS-onset criteria. Given that PTS cannot be ethically or legally induced in animals to determine the threshold, Southall *et al*. (2007) proposed that noise exposure criteria for PTS-onset should be extrapolated from the onset of TTS based on the assumed relationships between the relative levels of noise likely to cause TTS and PTS.

7.5.2.12 As marine mammals rely heavily on their underwater auditory sense, it may be assumed that PTS will affect an individual's long-term fitness and survival. Therefore, following the precautionary approach described above for Southall *et al*. (2007), JNCC (2010) recommend the use of PTS-onset to define permanent auditory injury from underwater noise.

7.5.2.13 The impact criteria previously used to determine the onset of PTS and fleeing (TTS onset) for offshore wind farm assessments were typically those recommended by Southall *et al*., (2007). These have subsequently been revised by NOAA to reflect the current state of scientific knowledge regarding the characteristics of sound that have the potential to impact marine mammal hearing sensitivity (NMFS, 2016).

7.5.2.14 The new NOAA guidance proposes new refinements to the frequency weightings of the marine mammal hearing groups in addition to revising the thresholds for the onset of PTS and TTS using the dual metrics of Sound Pressure Level (SPL) and Sound Exposure Level (SEL). The criteria for SEL are estimated from studies of exposure of animals to a single pulse, however, these are also applied to cumulative SEL and therefore may be precautionary in this respect. The criteria applied are detailed in the Subsea Noise Technical Report (PEIR volume 4, annex 3.1).

Fleeing response (TTS onset)

7.5.2.15 The onset of TTS is taken as the level at which exposed animals could experience temporary auditory injury. This is precautionary as it assumes that the hearing of all individuals will be affected in the same way. This is unlikely to be the case, as demonstrated by Finneran *et al*. (2005), in a study which looked at the proportion of individual harbour porpoise exposed to different SELs that experienced TTS as a result of the sound exposure. This study revealed that to induce TTS in just 50% of animals, it would be necessary to extrapolate well beyond the range of measured SEL levels and suggests that for a given species, the potential effects follow a dose-response curve such that the probability of inducing TTS will decrease moving further away from the SEL threshold required to induce TTS. Though this study focused on SEL, the same is likely to hold true for the SPLpeak TTS criteria. The ecological effect of TTS depends not only on the magnitude of the TTS, its duration (depending on the exposure duration), and the recovery time after the exposure ceases, but also on the frequency at which hearing is affected and whether this frequency is important, for example, for echolocation (Kastelein *et al*., 2013). The most likely response of marine mammals to noise levels that could induce TTS is to flee from the ensonified area (Southall *et al*., 2007). Subsequently, the onset of TTS is often referred to as the 'fleeing response' threshold and as an animal flees an area its exposure to the noise level decreases and therefore the likelihood of TTS is reduced.

Behavioural effects

7.5.2.16 Studies of the behavioural responses of marine species to sound, describe a variety of different behavioural reactions. At lower levels, anthropogenic noise may temporarily impair hearing, cause stress or disturbance to behaviour by disrupting communication, echolocation or threat detection. Based on this, JNCC (2010) define disturbance in terms of animals incurring a sustained or chronic disruption of behaviour, or undergoing a significant change from their expected distribution.

7.5.2.17 Whilst it is widely acknowledged that hearing sensitivity of the animal is a key factor (Finneran and Schlundt, 2011; Terhune, 2013 and Nedwell *et al*., 2007b), the context of the exposure is also likely to have an influence on behaviour, in addition to the level of the underlying ambient noise (i.e., the perceived signal-to-noise ratio). Clearly, the frequency characteristics of the source need to be taken into account, as does the type of sound exposure (Southall *et al.,* 2007).

7.5.2.18 For behavioural disturbance of cetaceans to multiple pulse noise (such as piling noise) Southall *et al.* (2007) developed a severity scaling which accounts for the duration of the sound producing activity. Severity scales of 4 to 6 are considered to have potential to affect foraging, reproduction, or survival. Specifically, a severity score of 5 indicates a change in swimming behaviour and modification of vocalisations but not avoidance, and 6 indicates startle responses, aggressive reactions to noise and minor to moderate avoidance.

7.5.2.19 There are no equivalent criteria for behavioural effects for pinnipeds in Southall *et al*. (2007) and therefore the criterion most commonly used for behavioural disturbance is the same as for onset of TTS/fleeing (Table 7.10). This would be considered to be at the upper end of the behavioural scale as it is assumed that animals subjected to noise levels that elicit TTS/fleeing would be displaced from the affected area.

Assessment approach

7.5.2.20 For the Draft Report to Inform Appropriate Assessment there have been two agreed approaches with regards to the assessment of underwater noise impacts (EWG). Details of which are provided below.

7.5.2.21 With regards 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 were applied within the underwater noise modelling (PEIR volume 4, annex3.1 Subsea noise technical report) which has subsequently been used to inform this element of the assessment.

7.5.2.22 There are no specific criteria for behavioural effects for pinnipeds outlined in Southall *et al*. (2007) and therefore the criterion most commonly used for behavioural disturbance is the same as for onset of TTS/fleeing. The ranges over which the onset of TTS/fleeing (referred to also as 'displacement' in this assessment) for pinnipeds are out to 1 km from the source. This approach is considered to provide sufficient detail to inform an Appropriate Assessment of the European sites and their qualifying features, in view of their Conservation Objectives, screened in for consideration.

7.5.2.23 With regards to disturbance effects on harbour porpoise qualifying features, it was advised at the EWG meeting (28th March 2017, see Annex 2: draft Evidence Plan), that a uniform approach, based on observed harbour porpoise behavioural evidence be adopted for the disturbance assumptions when characterising significant disturbance effects (i.e., displacement) of the harbour porpoise Southern North Sea cSAC feature.

7.5.2.24 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 significant 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.

7.5.2.25 Harbour porpoise are currently considered as being of Favourable Conservation Status (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, however these may be subject to change. 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.

7.5.2.26 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 .

7.5.2.27 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 433 days phased over a 2.5 year period, while for jacket foundations with single piling, piling is likely to occur on 605 days phased over a 2.5 year period. This programme is based on Hornsea Three being constructed in a single phase, the period will change if the project is constructed in two or three phases but the number of piling days will remained the same. 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 any piling noise should for the purpose of assessment equates to a 24 hour period. Therefore, the piling window significantly over estimates the possible piling duration.

7.5.2.28 The assessment approach detailed above has been discussed and agreed with the Marine Mammal EWG.

<u>Potential effect: lethality/ injury</u>

7.5.2.29 The conclusions of HRA Screening report found that, for Hornsea Three, the potential for injurious effects would be in relation to noise associated with underwater piling operations. It is not possible to quantify the effects of UXO detonations at this stage. It has been agreed (Marine Mammal EWG, 2017) that the assessment of impacts associated with UXO clearance will be considered during the application of a separate marine licence for these activities.

7.5.2.30 High levels of noise exposure can cause an instantaneous auditory injury resulting in a Permanent Threshold Shift (PTS) that persists once sound exposure has ceased. Thus, an estimate of the range out to which PTS could occur, for each marine mammal hearing group that are qualifying features of the sites under consideration, was modelled using the SPL_{peak} thresholds given in NMFS (2016) (Table 7.10). In addition, PTS may also result from prolonged exposure at lower levels sufficient to cause a Temporary Threshold Shift (TTS). Although animals are able to recover fully from TTS, particularly as they move away from the sound source, hearing loss may become permanent if hearing does not return to normal after several weeks. Therefore, the distinction between TTS and PTS depends on whether there is complete recovery of the individual's hearing.

7.5.2.31 The criteria used to look at prolonged exposure leading to Auditory Injury (PTS) is cumulative sound exposure levels (SEL_{cum}) and these are weighted according to the hearing range of each of the marine mammal groups. Due to the potential for overestimating the effect ranges using marine mammal weighted SEL_{cum}, these criteria have not been applied to this marine mammal impact assessment (as agreed with the Marine Mammal EWG).

7.5.2.32 Since a soft-start would be initiated at 15% of the maximum hammer energy, the range out to which injury could occur from the initial strike of the hammer (375 kJ soft start for 2,500 kJ hammer and 750 kJ soft start for 5,000 kJ hammer) dictated the extent over which mitigation should be applied (if required), as agreed with the Marine Mammal EWG (see Table 5.6).

Table 7.10: Ranges and areas over which PTS could occur in Annex II marine mammal qualifying features as a result of single and concurrent piling at Hornsea Three array area for pin piles (2,500 kJ) and monopiles (5,000 kJ).

Marine mammal hearing group and associated Annex II features	Threshold SPL$_{peak}$ (dB re. 1µPa) [a]	Range (m): maximum (mean) [b]	Area (km^2) single piling: maximum (mean)	Area (km^2) concurrent piling: maximum (mean) [c]
375 kJ (15% soft start for 2,500 kJ maximum energy)				
High Frequency Cetaceans (harbour porpoise)	202	280 (149)	0.25 (0.07)	N/A
Pinnipeds (grey seal and harbour seal)	218	11 (9)	0.0004 (0.0003)	N/A
750 kJ (15% soft start for 5,000 kJ maximum energy)				
High Frequency Cetaceans (harbour porpoise)	202	1,500 (660)	7.07 (1.37)	14.14 (2.74)
Pinnipeds (grey seal and harbour seal)	218	42 (28)	0.006 (0.002)	0.012 (0.004)

a Unweighted SPL peak criteria from NMFS (2016).
b Ranges presented are based on the maximum and mean (in parenthesis) propagation at 15% soft start energy for the location (south, northwest, or northeast) that resulted in the largest ranges.
c To estimate the area of effect for concurrent piling (for the 5,000 kJ hammer only) the areas for single piling were doubled.

7.5.2.33 In order to adopt a precautionary approach, the noise modelling assessment considered the greatest range over which PTS could occur across all locations modelled either within the Hornsea Three array area or within the offshore HVAC booster station search area. Within the Hornsea Three array area, the greatest range out to which PTS could occur was for harbour porpoise and was estimated at 280 m for a soft start energy of 375 kJ hammer and 1,500 m for a soft start energy of 750 kJ (Table 7.10). Similarly, within the offshore HVAC booster station search area, PTS was estimated out to a maximum range of 200 m and 1100 m for HF cetaceans initiating with a soft start of 375 kJ and 750 kJ respectively (Table 7.11). For pinnipeds and in both the Hornsea Three array area and offshore HVAC booster station search area, the ranges were much smaller and within a few tens of metres maximum (Table 7.10 and Table 7.11).

7.5.2.34 Areas of impact have also been presented in Table 7.10 and Table 7.11 for piling using a single vessel with either the 2,500 kJ (for pin piles) or 5,000 kJ (for monopiles) hammer energy using πr^2, where radius 'r' = range. A scenario of concurrent piling vessels is only applicable to the installation of monopiles within the Hornsea Three array area and therefore areas are presented for the 5,000 kJ hammer energy only (Table 5.2). The area of impact has been estimated for concurrent piling (which assumes that vessels are piling at opposite ends of the site, by simply doubling the area estimated for the single piling scenario.

Table 7.11: Ranges and areas over which PTS could occur in Annex II marine mammal qualifying features as a result of piling at a single location within the offshore HVAC booster station search area for pin piles (2,500 kJ) and monopiles (5,000 kJ).

Marine mammal hearing group and associated Annex II features	Threshold SPL$_{peak}$ (dB re. 1µPa) [a]	Range (m): maximum (mean) [b]	Area (km^2): maximum (mean)
375 kJ (15% soft start for 2,500 kJ maximum energy)			
High Frequency Cetacean (harbour porpoise)	202	200 (120)	0.13 (0.05)
Pinnipeds (grey seal and harbour seal)	218	8 (7)	0.0002 (0.0002)
750 kJ (15% soft start for 5,000 kJ maximum energy)			
High Frequency Cetacean (harbour porpoise)	202	1100 (520)	3.80 (0.85)
Pinnipeds (grey seal and harbour seal)	218	31 (21)	0.003 (0.002)

a Unweighted SPL peak criteria from NMFS (2016).
b Ranges presented are based on the maximum and mean (in parenthesis) propagation at 15% soft start energy for the location (north or south) that resulted in the largest ranges.

7.5.2.35 Based on the results in Table 7.10 and Table 7.11, the maximum extent over which mitigation would need to be applied to avoid injury to any species of marine mammal is 1,500 m (Table 5.6). This has been agreed with the Marine Mammal EWG and details of mitigation measures to be adopted will be included in the MMMP (Marine Mammal Management Plan).

7.5.2.36 Another way to investigate the potential for PTS to occur is to consider the injury ranges as the hammer energy ramps up over the soft start procedure. As agreed with the Marine Mammal EWG, modelling was undertaken to predict the PTS injury ranges for the different marine mammal hearing groups during this ramp up. Results are presented in PEIR volume 4, annex 3.1: Subsea Noise Technical Report. For pinnipeds in water, the PTS ranges do not exceed 140 m at either of the maximum energies (2,500 kJ or 5,000 kJ) or at any location modelled (i.e. within the Hornsea Three array area or offshore HVAC booster station search area) (PEIR volume 4, annex3.1 Subsea noise technical report). Therefore, a mitigation zone of 1500 m will be sufficient to ensure injury does not occur in harbour seal or grey seal.

7.5.2.37 In contrast, the ranges at which PTS could occur in harbour porpoise increase from 1500 m at a 750 kJ soft start up to a range of 4.9 km at the 5,000 kJ hammer energy for the modelled 'south' location within the Hornsea Three array area (Table 7.12). In order to estimate whether there is potential for harbour porpoise to be exposed to noise levels that cause PTS as hammer energy ramps up, it was assumed that animals flee the area at a speed of 1.5 m^{-1}, based on the cruising speed of harbour porpoise (Otani *et al*., 2000), from a starting point of 1.5 km as the proposed distance over which mitigation should be implemented. It can be seen that, based on this precautionary swim speed, there is potential for animals to experience PTS over the ramp up procedure for the 5,000 kJ hammer as the distance that they clear during fleeing is less than the maximum ranges over which PTS is predicted to occur at 40%, 60% and 80% up to the maximum (Table 7.12).

Table 7.12: Ranges out to which PTS is predicted for harbour porpoise as hammer energy ramps up from soft start (15% blow energy) to maximum hammer energy (100% blow energy).

		15% blow energy	40% blow energy	60% blow energy	80% blow energy	100% blow energy
PTS range(m) for 2,500 kJ	Hornsea Three array area [a]	230 (150)	790 (470)	1,100 (690)	1,500 (860)	1,700 (1,000)
	Offshore HVAC booster station search area [a]	200 (120)	710 (380)	1,000 (560)	1,400 (700)	1,700 (870)
PTS range(m) 5,000 kJ	Hornsea Three array area [a]	1,500 (660)	2,900 (1,800)	3,800 (2,800)	4,300 (3,500)	4,900 (3,800)
	Offshore HVAC booster station search area [a]	1,100 (520)	2,300 (1,400)	2,900 (1,800)	3,600 (2,300)	3,900 (2,800)
Duration of piling		7.5 minutes	7.5 minutes	7.5 minutes	7.5 minutes	3 hours 30 minutes
Fleeing distance (m) [b]		1,500	2,175 (3,390)	2,850 (5,280)	3,525 (7,170)	4,200 (9,060)

a Ranges presented are for the maximum and mean (in parenthesis) propagation based on pile-driving at location 'south' in the Hornsea Three array and location 'south' in the offshore HVAC booster station search area, as the locations that resulted in the largest ranges.

b Fleeing distance has been estimated for harbour porpoise based on how far an animal can swim over each 7.5 minute step in piling using conservative estimates of 1.5 ms^{-1} for mean cruising speed and 4.2 ms^{-1} for maximum cruising speed (in parenthesis).

7.5.2.38 Hornsea Three are currently considering further refinements to the ramp up procedure which may mitigate potential injury. It should, however, be noted that there needs to be a careful balance between ensuring PTS does not occur and increasing the duration of pile-driving (by increasing the duration of soft start) particularly as the fleeing distances are likely to be underestimated using the precautionary swim speed of 1.5 m^{-1}. For example, the fleeing speed is based on the maximum cruising speed recorded by Otani *et al.* (2000 and 2001) of 4.2 m^{-1} this would suggest that harbour porpoise could potentially increase their distance by 1,890 m for each 7.5 minute step in piling. Thus, when 100% hammer energy is finally reached, an animal could potentially be up to 9 km from the piling and at each step will be beyond the range of potential injury (Table 7.12).

7.5.2.39 In the absence of mitigation, there is potential for a small number of harbour porpoise to experience PTS up to the maximum hammer energies (2,500 kJ and 5,000 kJ) during pile-driving both within the Hornsea Three array area and offshore HVAC booster station search area (Table 7.13 and Table 7.14). NB TTS effect ranges have been included for information in Table 7.13 and Table 7.14 although the thresholds are not for assessment of harbour porpoise displacement in this Draft Report to Inform Appropriate Assessment as discussed.

Table 7.13: Number of harbour porpoise potentially affected by pile-driving within the Hornsea Three array area and proportion of the reference population affected (NS MU harbour porpoise population = 227,298).

Threshold	Number of animals within noise contour: single piling	Percentage of NS MU population	Number of animals within noise contour: concurrent piling	Percentage of NS MU population
2,500 kJ				
PTS (15% soft start)	<1	0.0003	N/A	N/A
PTS (100% energy)	26	0.01	N/A	N/A
TTS	144	0.06	N/A	N/A
5,000 kJ				
PTS (15% soft start)	20	0.009	40	0.018
PTS (100% energy)	217	0.10	434	0.20
TTS	1,477	0.65	2,954	1.30

Table 7.14: Number of harbour porpoise potentially affected by pile-driving (single vessel) within the offshore HVAC booster station search area and proportion of the reference population affected (NS MU harbour porpoise population = 227,298).

Threshold	Number of animals within noise contour	Percentage of NS MU population
2,500 kJ		
PTS (15% soft start)	<1	0.0002
PTS (100% energy)	26	0.01
TTS	104	0.05
5,000 kJ		
PTS (15% soft start)	11	0.005
PTS (100% energy)	137	0.06
TTS	730	0.32

7.5.2.40 The number of harbour porpoise potentially affected by TTS was also relatively small for piling within the Hornsea Three array area, although there was an approximate 10 fold increase in the numbers affected during single vessel piling for the 5,000 kJ hammer compared with the smaller 2,500 kJ hammer and more so where the maximum design spatial scenario is considered for concurrent piling at 5,000 kJ (Table 7.14). However, as the maximum spatial design scenario for concurrent piling will lead to a shorter piling duration, the overall impact on harbour porpoise from concurrent piling using 5,000 kJ hammer energy may be similar to single location piling using the same hammer energy.

7.5.2.41 Marine mammals, and odontocetes in particular (due to their echolocation ability), rely mainly on their high frequency hearing for orientation and foraging. Therefore, these high frequencies are likely to be more ecologically important to them than low frequencies. Kastelein *et al*. (2012a) exposed a harbour porpoise to a 1.5 kHz continuous tone at a mean received sound pressure level (SPL) of 136 dB re.1µPa, and found that the animal's hearing around 125 kHz was not influenced (i.e., no TTS likely to affect echolocation ability occurred). This was expected, as frequencies between 1 and 2 kHz, and echolocation signals (of approximately 125 kHz), are processed in different parts of the ear (Kastelein *et al.*, 2013). Hearing thresholds of harbour porpoise for the frequencies of their echolocation signals are not affected by intense low frequency sounds, and these sounds are unlikely to affect echolocation ability, and therefore foraging efficiency (Kastelein *et al.*, 2013). Following on from this, TTS resulting from sound sources such as piling, where most of the energy occurs at lower frequencies, is unlikely to negatively affect the ability of harbour porpoise for echolocation (foraging and navigation).

7.5.2.42 The piling duration is estimated as 604.8 days (temporal maximum design) phased over 2.5 years, equivalent of up to ~21% of the species lifespan; piling would however occur intermittently over this period (i.e. four to eight hours per 24 hour period). This is considered to be very precautionary as it assumes the longest duration of piling would occur at each location and that the minimum number of piles would be installed in any one 24 hour period. In practice, both the duration of piling and the number of days on which piling occurs would be considerably less than currently described for the maximum design scenario.

7.5.2.43 The modelled ranges of effect can be viewed in the volume 4, annex 3.1: Subsea Noise Technical Report, but should be treated with caution as it is likely that they are unrealistic due to the precautionary assumptions applied in the model, including:

- The maximum noise level vertically in the water column was used in the SEL_{cum} model which assumes that an animal is at the loudest position at all times therefore the model overestimates the noise exposure an animal receives since it does not account for any time that marine mammals spend at the surface, the reduced sound levels near the surface, nor the temporal hearing recovery between piling sequences;
- A precautionary swim speed of 1.5 ms^{-1} was adopted for all marine mammals, therefore the model would overestimate the received noise levels for animals that swim faster than these speeds;
- The modelling did not take into account the reduction in 'sharpness' of the noise as noise spreads over distance which would lead to lower peak levels than predicted by the model, and therefore a reduced likelihood of experiencing PTS at greater ranges;
- The noise model applied precautionary values for parameters (e.g. water temperature) that would lead to the greatest ranges;
- The noise model assumed that SEL_{cum} starts at the source location, whereas if mitigation were applied to deter animals out to a range of 1,500 m the noise levels experience by fleeing animals would be much lower and lead to a reduced likelihood of PTS;
- The soft-start procedure simulated did not allow for short pauses in piling (e.g. for realignment), and therefore the modelled SELcum is likely to be an overestimate since, in reality, these pauses will reduce the noise exposure that animals experience whilst fleeing; and
- The model assumed that the maximum hammer energy would be achieved at the end of the soft start and continue throughout the remainder of the piling sequence, whereas in reality it more likely that the maximum energy would only be required for a very short duration at the end of the piling sequence, if at all.

Conclusions

The Wash and North Norfolk Coast SAC

7.5.2.44 Based on the information presented above there is no indication that lethality/ injury and hearing impairment 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 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. 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

7.5.2.45 Based on the information presented above there is no indication that lethality/ injury and hearing impairment 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 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. 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

7.5.2.46 Based on the information presented above, there is no indication that the potential for lethality/ 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. 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. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI (harbour porpoise behaviour effects assessed separately)

7.5.2.47 Based on the information presented above, there is no indication that the potential for lethality/ injury and hearing impairment effects associated with underwater noise on the harbour and grey seal and 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. 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 features of this SCI.

Doggersbanks SCI

7.5.2.48 Based on the information presented above, there is no indication that the potential for lethality/ injury and hearing impairment 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 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

7.5.2.49 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 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 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.

<u>Potential effect: pinniped disturbance/displacement (TTS/Fleeing)</u>

7.5.2.50 The ranges and areas of effect out to which TTS onset and therefore displacement could occur for pinniped qualifying features under consideration in this report in the following tables for the Hornsea Three array area are presented in Table 7.15 for the array area and Table 7.16 for the offshore HVAC booster station search area.

Table 7.15: Ranges and areas over which fleeing (TTS onset) and therefore displacement could occur in pinnipeds, as a result of single and concurrent piling at Hornsea Three array area for pin piles (2,500 kJ) and monopiles (5,000 kJ).

Marine mammal hearing group	Threshold SPL$_{peak}$ (dB re. 1µPa) [a]	Range (m): maximum (mean) [b]	Area (km^2) single piling: maximum (mean)	Area (km^2) concurrent piling: maximum (mean) [c]
2,500 kJ				
Pinnipeds	212	260 (170)	0.21 (0.09)	0.42 (0.18)
5,000 kJ				
Pinnipeds	212	1,000 (480)	3.14 (0.72)	6.28 (1.44)

a Unweighted SPL peak criteria from NMFS (2016).
b Ranges presented are based on the maximum and mean (in parenthesis) propagation from the selected location for each species.
c To estimate the area of effect for concurrent piling (for the 5,000 kJ hammer only) the areas for single piling were doubled.

Table 7.16: Ranges over which fleeing (TTS onset) and therefore displacement could occur in pinnipeds, as a result of piling at a single location within the offshore HVAC booster station search area for pin piles (2,500 kJ) and monopiles (5,000 kJ).

Marine mammal hearing group	Threshold SPL$_{peak}$ (dB re. 1µPa)[a]	Range (m)[b]: maximum (mean)	Area (km^2): maximum (mean)
2,500 kJ			
Pinnipeds	212	250 (140)	0.20 (0.06)
5,000 kJ			
Pinnipeds	212	1,000 (440)	3.14 (0.06)

a unweighted SPL peak criteria from NMFS (2016).
b Ranges presented are based on the maximum and mean (in parenthesis) propagation for the location (south or north) that resulted in the largest ranges.

Grey seal

7.5.2.51 Traditionally noise impact assessments for offshore wind projects have assumed that all animals within the zone of impact may be affected to the same degree to ensure a precautionary assessment of impact. For example, assessments would have assumed that all animals exposed to noise levels that induce disturbance will move away from the affected area. However, evidence from the published literature suggests that this may lead to predictions that are over-precautionary and therefore unrealistic. For example, a study looking at the proportion of trials at different SELs that result in TTS in exposed animals revealed that to induce TTS in just 50% of animals it would be necessary to extrapolate well beyond the range of measured SEL levels (Finneran *et al*., 2005).

7.5.2.52 The range of effect for injury to pinnipeds is small (up to 42 m maximum during soft start Table 7.10) and therefore the number of animals potentially affected is very small (less than one for all scenarios). With measures adopted as part of Hornsea Three in place (MMMP and soft start piling) it is considered unlikely that an injury would occur to grey seal during pile driving either within the Hornsea Three array area (Table 7.17) or offshore HVAC booster station search area (Table 7.18). Similarly, very small numbers of grey seal were predicted to occur within the zone of potential TTS/fleeing.

Table 7.17: Number of grey seal potentially affected by pile-driving within the Hornsea Three array area and proportion of the reference population affected (SEE and NEE MU grey seal population = 18,150).

Threshold	Number of animals within noise contour: single piling	Percentage of SEE+NEE MU population	Number of animals within noise contour: concurrent piling	Percentage of SEE+NEE MU population
2,500 kJ				
Auditory injury (PTS) (15% soft start)	<1	<0.000001	<1	<0.000001
TTS/fleeing (displacement)	<1	0.002	<1	0.003
5,000 kJ				
Auditory injury (PTS) (15% soft start)	<1	<0.00001	<1	<0.00001
TTS/fleeing (displacement)	<1	0.003	1	0.006

Table 7.18: Number of grey seal potentially affected by pile-driving (single vessel) within the offshore HVAC booster station search area and proportion of the reference population affected (SEE and NEE MU grey seal population = 18,150).

Threshold	Number of animals within noise contour	Percentage of SEE+NEE MU population
2,500 kJ		
Auditory injury (PTS) (15% soft start)	<1	<0.000001
TTS/fleeing (displacement)	<1	0.002
5,000 kJ		
Auditory injury (PTS) (15% soft start)	<1	<0.00001
TTS/fleeing (displacement)	<1	0.03

7.5.2.53 Piling duration is estimated as 604.8 days (temporal maximum design) phased over 2.5 years, equivalent of up to ~13% of the species lifespan; piling would however occur intermittently over this period (i.e. four to eight hours per 24 hour period). This is considered to be very precautionary as it assumes the maximum hours of piling at each location and the maximum days on which piling could occur will be required.

7.5.2.54 A range of effects arising from subsea noise during piling haves been assessed for grey seal, from potential auditory injury to possible disturbance. Against a background of increasing numbers of grey seal within the regional marine mammal study area it is considered unlikely that behavioural disturbance could lead to any population level effects due to the small proportion of the SEE and NEE MU population affected.

Harbour seal

7.5.2.55 As described above the range of effect for injury to pinnipeds is small with a maximum of 42 m affected during soft start. With measures adopted as part of Hornsea Three in place (an MMMP and soft start piling) it is considered unlikely that an injury would occur to harbour seal during pile driving either within the Hornsea Three array area (Table 7.19) or offshore HVAC booster station search area Table 7.20). Less than one harbour seal was predicted to occur within the zone of potential TTS/fleeing for any of the scenarios within the Hornsea Three array area or offshore HVAC booster station search area.

Table 7.19: Number of harbour seal potentially affected by pile-driving within the Hornsea Three array area and proportion of the reference population affected (SEE MU harbour seal population = 3,567).

Threshold	Number of animals within noise contour: single piling	Percentage of SEE MU population	Number of animals within noise contour: concurrent piling	Percentage of SEE MU population
2,500 kJ				
Auditory injury (PTS) (15% soft start)	<1	<0.000001	<1	0.0007
TTS/fleeing (displacement)	<1	0.005	<1	0.01
5,000 kJ				
Auditory injury (PTS) (15% soft start)	<1	0.0001	<1	0.0002
TTS/fleeing (displacement)	<1	0.007	<1	0.014

Table 7.20: Number of harbour seal potentially affected by pile-driving (single vessel) within the offshore HVAC booster station search area and proportion of the reference population affected (SEE MU harbour seal population = 3,567).

Threshold	Number of animals within noise contour	Percentage of SEE MU population
2,500 kJ		
Auditory injury (PTS) (15% soft start)	<1	<0.000001
TTS/fleeing (displacement)	<1	0.005
5,000 kJ		
Auditory injury (PTS) (15% soft start)	<1	<0.00001
TTS/fleeing (displacement)	3	0.07

7.5.2.56 Due to the small proportion of the population affected it is considered unlikely that there will be any population-level effects and animals affected are expected to return to baseline levels following cessation of the activity. Evidence for this comes from a recent population modelling study for the effects of piling at the Moray Firth and Beatrice proposed offshore wind farms on harbour seal (Thompson *et al.*, 2013). This study looked at the long-term effects on the population as a result of short to medium-term decreases in the population, including both potential mortality of animals exposed to noise levels that would induce PTS and behavioural displacement. The results of the modelling showed that over a 25 year period, even with considerable reductions in the population during the piling phase, for all worst case spatial and temporal scenarios, the population of harbour seals would recover in the long term.

7.5.2.57 Piling duration is estimated as 604.8 days (temporal maximum design) phased over 2.5 years, equivalent of up to ~13% of the species lifespan; piling would however occur intermittently over this period (i.e. four to eight hours per 24 hour period). This is considered to be very precautionary as it assumes the maximum hours of piling at each location and the maximum days on which piling could occur will be required.

7.5.2.58 Numbers of harbour seal within the regional marine mammal study area have shown a steady increase since 2006 and it is considered unlikely that behavioural disturbance could lead to any population level effects due to the small proportion of the SEE MU population affected.

Conclusions

The Wash and North Norfolk Coast SAC

7.5.2.59 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. 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. 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

7.5.2.60 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. 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. 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)

7.5.2.61 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. 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 features of this SCI.

Doggersbanks SCI

7.5.2.62 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. 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 features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

7.5.2.63 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. 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.

<u>Potential effect: harbour porpoise disturbance</u>

7.5.2.64 The conclusions of LSE found that, for Hornsea Three, the potential for significant disturbance would be in relation to noise associated with underwater piling operations. It is not possible to quantify the effects of UXO detonations at this stage. Assessment of impacts associated with UXO clearance will be considered during the application of a separate marine licence for these activities. 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 during periods of such noisy activity. For the Southern North Sea (cSAC), the only UK European site with harbour porpoise as a feature, the driver behind the conservation objective 'there is no significant disturbance of the species' is to ensure that any such displacement disturbance is not significant in terms of extent and duration.

Potential for disturbance effects

7.5.2.65 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;
  - 342 WTG foundations (7 m diameter),
  - 3 offshore accommodation platforms,
  - 12 HVAC collector substations; and
  - 4 offshore HVAC booster stations.

- Jack foundations with single piling;
  - 342 WTG foundations (four piles per foundation totalling 1368 piles),
  - 3 offshore accommodation platforms,
  - 12 HVAC collector substations; and
  - 4 offshore HVAC booster stations.

7.5.2.66 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 7.21) 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 1,368 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.

7.5.2.67 Table 7.21 identifies the maximum 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 maximum range is 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 Figure 7.9. Only the spatial extent of concurrent piling has been presented in Figure 7.9 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 7.21: Maximum spatial overlap with the cSAC from piled project components

Project component	Spatial overlap with the summer component of the cSAC (%)	
	Maximum	Minimum
Singular		
WTG	1.6	6.3×10^{-6}
HVAC booster stations	6.4	1.3
Concurrent		
WTG	1.83	6.2×10^{-4}
HVAC booster stations	6.4	1.3

7.5.2.68 The total level of overlap (WTG and HVAC booster stations) with the cSAC from all piling activities ranges from 8% (1.6% for WTG plus 6.4% for HVAC) to 1.3% for sequential piling and 8.23% (1.83% for WTG plus 6.4% for HVAC) to 1.3% for concurrent piling. No foundation piling under any construction scenario will result in a spatial effect greater than 8.23% 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. 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 0.73%, which will not exceed the 20% threshold value in any given day.

7.5.2.69 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 605 days phased over a 2.5 year piling phase, which results in approximately 20 piling days per month when averaged across the time period. 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 four days piling over the winter season.

7.5.2.70 When averaged across the entire piling window, approximately 120 piling days will occur across any one summer season (20 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 (120 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 0.35%. This value is well below the 10% effect threshold value.

7.5.2.71 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 0.73% 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 four 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 0.016%.

Consideration of return times

7.5.2.72 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.

7.5.2.73 The maximum duration of piling activity is for 605 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 20 piling days per month, which could affect the summer component of the cSAC or four days per month. The outputs of the maximum spatial overlap at any one time and across the season are based upon a full days piling noise. Therefore, there is a period of return time built into the assessment (16 hours, based on 4 hours piling per monopile and maximum of two monopiles per day).

7.5.2.74 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.*, (2012)[7] 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 (360 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 0.68%.

7.5.2.75 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 12 days. Therefore, the percentage overlap over the winter component, with the additional of the return, is 0.048%.

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.

[7] Thompson, P. M., Lusseau, D., Barton, T., Simmons, D., Rusin, J., Bailey, H. (2012). Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin, 60: 1200-1208.

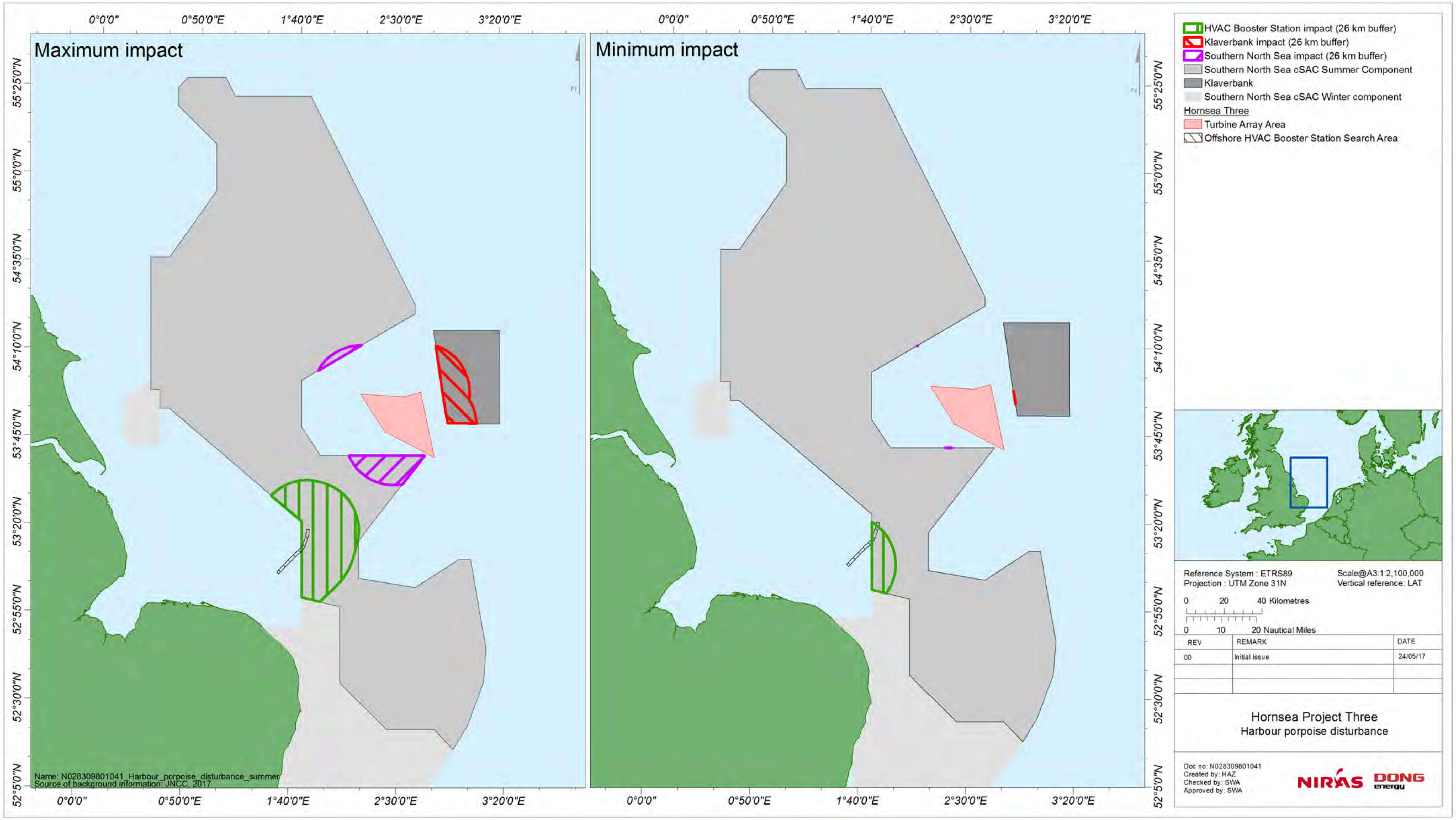

Figure 7.9: Spatial extent of disturbance from concurrent piling at Hornsea Three.

Conclusions

7.5.2.76 Based on the information presented above, there is no indication that the potential for behavioural 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. 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. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Transboundary disturbance effects – Klaverbank SCI

7.5.2.77 Following the approach utilised for assessing disturbance on the Southern North Sea cSAC, the precautionary distance of 26km 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 (as characterised by spatial overlap of the 26 km buffer with the Klaverbank SCI) varies depending on the location of the foundation. The further away the piling location from the SCI the less spatial overlap. This variation can be presented as a range, in line with the approach used for the Southern North Sea cSAC assessment.

7.5.2.78 Table 7.22 identifies the maximum 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 7.9. Only the spatial extent of concurrent piling has been presented as this represents the maximum design scenario.

Table 7.22: Maximum spatial overlap with the Klaverbank SCI from piled project components

Project component	Spatial overlap with the summer component of the Klaverbank SCI (%)	
	Maximum	Minimum
Singular		
WTG	30.2	0.03
Concurrent		
WTG	34.2	0.094

7.5.2.79 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. When the 26 km buffer is applied to each WTG, 31 piling events result in a spatial overlap of over 20% with the Klaverbank SCI. The remaining piling events affect less than 20% of the Klaverbank SCI.

7.5.2.80 The disturbance occurring from piling events is limited temporally, with only 31 events over either 2.5 years or 3 years effecting over 20% of the Klaverbank SCI. Whilst there are likely to be immediate effects of piling on harbour porpoise, in terms of potential disturbance, a key consideration is whether this disturbance will lead to longer term population effects.

7.5.2.81 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.

7.5.2.82 Klaverbank SCI is not described as having seasonal components, therefore disturbance has also been assessed across the entire year. The maximum design scenario outlines that piling is likely to occur on 605 days phased over a 2.5 year piling phase, which results in approximately 20 piling days per month when averaged across the time period (equalling 240 days over a full year).

7.5.2.83 To identify the average spatial extent across a year, the mean of spatial overlap for the piling locations has been calculated. The average spatial extent of disturbance within the Klaverbank SCI for all the pile locations equals 5.98%. To average such an affect across a year, the spatial effect is then applied to the approximate number of piling days in a year (240 days out of 365). 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 year. In any one year, the maximum spatial extent of disturbance equals 3.93%. This value is below the 10% effect threshold value.

7.5.2.84 It is important to consider return time within the assessments, with evidence suggesting that this may range from a few hours, between 1 and 3 days (Tougaard *et al.*, 2014; 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).

7.5.2.85 The maximum duration of piling activity is for 605 days. 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). When averaged evenly across the piling schedule, there will be 20 piling days per month or 240 across the year. This value is the same even if concurrent piling occurs due to the shortened time schedule. The outputs of the maximum spatial overlap at any one time and across the year are based upon a full days piling noise. Therefore, there is a period of return time built into the assessment (16 hours, based on 4 hours piling per monopile and maximum of two piles per day).

7.5.2.86 There is a considerable amount of time when piling is not occurring and the return of harbour porpoise could be expected. Consideration has been given to the maximum return time of 72 hours (following Thompson *et al.*, 2012). An additional two days has been added to every piling day when assessing the impact across the summer season (essentially extending the displacement period). This results in more piling days and return time days than are present within the year (720 days). Therefore the percentage spatial overlap over the year with the addition of the return time, equates in the average yearly footprint, to a value of 9.77%. 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.

Conclusions

7.5.2.87 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 reduction in the extent or quality of the habitat in order to maintain the populations. 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 features of this SCI.

Increased vessel traffic: noise and collision risk

7.5.2.88 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.

7.5.2.89 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.

7.5.2.90 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.

7.5.2.91 Though impacts associated with increased vessel movement have the potential to occur throughout the potential 11 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 11 year construction period, with a six year gap between similar construction activities (Table 5.2). It has been assumed that masking and potential for avoidance behaviour may occur several kilometres from the noise source for all species.

7.5.2.92 Comparative analysis undertaken by Subacoustech Ltd (PEIR 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. For example, impact piling of monopile or pin pile options was estimated to produce noise levels of 244 dB re 1 µPa @ 1 m (Peak) and 241 dB re 1 µPa @ 1 m (Peak) respectively, and cable laying and dredging as 171 dB re 1 µPa @ 1 m (root-mean-square (RMS)) and 186 dB re 1 µPa @ 1 m (RMS) respectively. Vessel movements from large vessels and small 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; much less than pile driving. 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.

7.5.2.93 Table 5.2 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 11 year offshore construction period, this would equate to a potential increase in vessel movements of approximately 5,888 per construction phase, or 2,356 per year, 78 per month or 6.45 per day during each 2.5 year construction phase within the 11 year offshore construction period. 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 5.6) to avoid any abrupt changes in speed and therefore increasing their predictability of movement to marine mammals.

7.5.2.94 The current level of vessel activity passing through the Hornsea Three array area plus 10 NM (shipping and navigation study area) is 41 vessels per day during the summer survey period (June and July) and 29 per day during the winter survey period (November to December). On average, this is 35 vessels per day (chapter 7: Shipping and Navigation). This is equal to 1,064 vessel movements per month or 12,775 vessel movements per year, within a 10 NM radius of Hornsea Three. 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.

7.5.2.95 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.

7.5.2.96 The impact is predicted to be of local spatial extent, medium term duration (11 year construction period), intermittent, and both reversible (in the case of increased noise), and irreversible (in the case of a collision).

7.5.2.97 The main source of noise from vessels comes from propeller cavitation and Senior *et al.* (2008) found that vessel noise increases with speed and loading for all vessel sizes. Reactions and are often linked to changes in the engine and propeller speed (Richardson *et al.*, 1995).

7.5.2.98 Studies have shown that unless the received vocalisation and masking noise come from the same direction, masking is unlikely to occur 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.

7.5.2.99 Hastie *et al.* 2003 observed changes in surface behaviour, and Palka and Hammond (2001) reported animals avoiding vessels. Harbour porpoise may be more sensitive to high frequency noise such as those associated with high-speed engines and are more likely to avoid vessels.

7.5.2.100 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).

7.5.2.101 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.

7.5.2.102 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). Collisions between vessels and marine mammals are not necessarily therefore lethal.

7.5.2.103 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).

<u>Conclusions</u>

The Wash and North Norfolk Coast SAC

7.5.2.104 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. 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.

The Humber Estuary SAC/Ramsar

7.5.2.105 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. 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.

The Southern North Sea cSAC

7.5.2.106 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. 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. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

7.5.2.107 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. 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. On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

7.5.2.108 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. 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 features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

7.5.2.109 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. 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.

Accidental pollution events

7.5.2.110 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 5.2). 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; paragraph 5.13.2.1) 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.

7.5.2.111 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 5.2). An impact upon marine mammal features would only be realised if an incident occurs where the fuel is accidentally released.

7.5.2.112 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 EMP will be developed (Table 5.6) 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 EMP 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.

7.5.2.113 The impact is predicted to be of local to regional spatial extent, short term duration, intermittent and reversible. It is predicted that the impact has the potential to affect marine mammal features both directly and indirectly. The magnitude is therefore, considered to be negligible.

7.5.2.114 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).

7.5.2.115 The release of oils is a serious concern for all marine mammals as the inhalation of toxic, volatile compounds could lead to mortality.

7.5.2.116 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).

7.5.2.117 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

7.5.2.118 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. 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.

The Humber Estuary SAC/Ramsar

7.5.2.119 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. 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.

The Southern North Sea cSAC

7.5.2.120 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. 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 cSAC.

Klaverbank SCI

7.5.2.121 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. 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 features of this SCI.

Doggersbanks SCI

7.5.2.122 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. 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 features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

7.5.2.123 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. 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.

7.5.3 Potential impacts - operation and maintenance

7.5.3.1 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 5.2 along with the maximum design scenario against which each operation and maintenance phase impact has been assessed.

Increased vessel traffic and collision risk

7.5.3.2 The potential impacts of increased vessel movement have been detailed above and have not been reiterated here.

7.5.3.3 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.

7.5.3.4 Table 5.1 details the type and number of operation and maintenance vessels predicted to be used over the 25 year duration of the operational lifetime of Hornsea Three.

7.5.3.5 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 25 year operation and maintenance phase of Hornsea Three, there is expected to be an increase of 2,832 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.

7.5.3.6 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.

7.5.3.7 The impact is predicted to be of local spatial extent, long term duration (25 year operational and maintenance period), intermittent, and both reversible (in the case of vessel noise), and irreversible (in the case of a collision).

7.5.3.8 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).

<u>Conclusions</u>

The Wash and North Norfolk Coast SAC

7.5.3.9 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 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. 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

7.5.3.10 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 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. 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

7.5.3.11 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. 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. On this basis there is no indication of an adverse effect on the Annex II qualifying feature of this cSAC.

Klaverbank SCI

7.5.3.12 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. 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. On this basis there is no indication of an adverse effect on the Annex II qualifying features of this SCI.

Doggersbanks SCI

7.5.3.13 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. 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 features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

7.5.3.14 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. 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.

Accidental pollution events

7.5.3.15 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.

7.5.3.16 The potential impacts of accidental pollution on marine mammals have been outlined above and have not been re-iterated here.

7.5.3.17 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 5.2 and PEIR volume 1, chapter 3: Project Description. The nacelle, tower and hub of the turbines will be designed to retain any leaks should they occur.

7.5.3.18 An EMP will be produced and implemented to cover the operation and maintenance phase of Hornsea Three (Table 5.6). This EMP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g. Environment Agency, Natural England and MCA).

7.5.3.19 Ant 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

7.5.3.20 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. 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.

The Humber Estuary SAC/Ramsar

7.5.3.21 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. 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.

The Southern North Sea cSAC

7.5.3.22 Based on the information presented above, there is no indication that effects associated with accidental pollution events would lead to a reduction in the 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. 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 cSAC.

Klaverbank SCI

7.5.3.23 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. 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 features of this SCI.

Doggersbanks SCI

7.5.3.24 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. 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 features of this SCI.

Noordzeekustzone SAC/ Noordzeekustzone II SCI

7.5.3.25 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. 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.

7.6 In-combination assessment methodology

7.6.1 Screening of other projects and plans

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 for the Draft Report to Inform Appropriate Assessment were initially identified from the results of a screening exercise undertaken for the PEIR (see PEIR volume 4, annex 5.2: Cumulative Effects Screening Matrix and PEIR 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 Draft Report to Inform Appropriate Assessment upon data confidence, effect-feature pathways and the spatial/temporal scales involved. Section 5.4 details the approach to the in-combination assessment.

7.6.1.2 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).

7.6.1.3 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 7.23).

7.6.1.4 During the initial screening exercise for marine mammals, projects were considered over the whole of the North Sea MU (Figure 7.5) 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.

7.6.1.5 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.

7.6.1.6 Information provided in PEIR 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.

7.6.1.7 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.

7.6.1.8 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.

7.6.1.9 With regards to increased vessel traffic, cables and pipelines are included if the operational phase has not already commenced (i.e. not part of the baseline).

7.6.1.10 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.

7.6.1.11 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.

7.6.1.12 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.

7.6.1.13 The specific projects scoped into this assessment and the Tiers into which these projects have been allocated, are outlined in Table 7.23 and illustrated in Figure 7.10 and Figure 7.11. 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.

7.6.1.14 As with the alone assessments , based on the fact that all the European sites screened in for assessment (Table 7.1) are located with the same North Sea MU (see Figure 7.5 and Figure 7.7) 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 7.1.

7.6.1.15 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.

7.6.2 Maximum design scenario

7.6.2.1 The maximum design scenarios identified in Table 7.24 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 (PEIR 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.

7.6.3 In-combination screening conclusions

7.6.3.1 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 Favourable Conservation Status (FCS) of the species of the designated sites being assessed.

7.6.3.2 The following impacts set out in 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; and

7.6.3.3 In addition to being screened out of the assessment of in-combination impacts due to a negligible impact for Hornsea Three alone, accidental pollution events during the construction phase resulting in potential effects on marine mammal features has also been screened out due to the assumption that management measures, similar to those being employed for Hornsea Three, will also be in place for the other projects considered within the assessment. These management measures will reduce the risk of these events occurring and minimise the magnitude of the impact, should these occur (e.g. CoCP and PEMMP, see Table 5.6).

7.6.3.4 It should be noted that the in-combination assessment presented in this marine mammal section 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 marine mammal would likely be reduced from those presented here. In addition, Hornsea Three is currently considering how the different levels of certainty associated with projects in Tier 1 can be reflected in the in-combination assessment and an update, in terms to the approach to tiering, will be presented in the Final Report to Inform Appropriate Assessment.

7.6.3.5 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, all Tier 3 projects have been scoped out of the assessment.

7.6.3.6 *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.
- 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 7.23: 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	174 turbines to be installed	2018 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		No	Yes
		Blyth demo	258	273	Up to 15 turbines consented, five constructed	2017	No	Yes
		Dogger Bank Creyke Beck A and B	76	91	Up to 200 turbines consented	2021 to 2024	Yes	Yes
		East Anglia One	152	106	102 x 7 MW turbines consented	2019	No	Yes
		Hornsea Project Two	7	8	Up to 300 turbines consented	2017 to 2019	No	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
		Dogger Bank Teesside A and B	95	108	Up to 400 turbines consented	2023 to 2026	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	Unknown	Unknown	Unknown
		Inch Cape	384	401	Up to 110 turbines	Unknown	Unknown	Unknown
		SeaGreen (Alpha, Bravo, Charlie, Delta, Echo, Golf, Foxtrot)	367	384	Up to 75 turbines per sub-project	Unknown	Unknown	Unknown
		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
	Submitted	East Anglia Three	103	87	Up to 172 turbines	2020 to 2022	Yes	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
		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

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
		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
		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
2	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	
	Cables and pipelines							
	Proposed	Viking Link Interconnector	13	18	High voltage (up to 500 kV) DC electricity interconnector	TBC	TBC	Yes

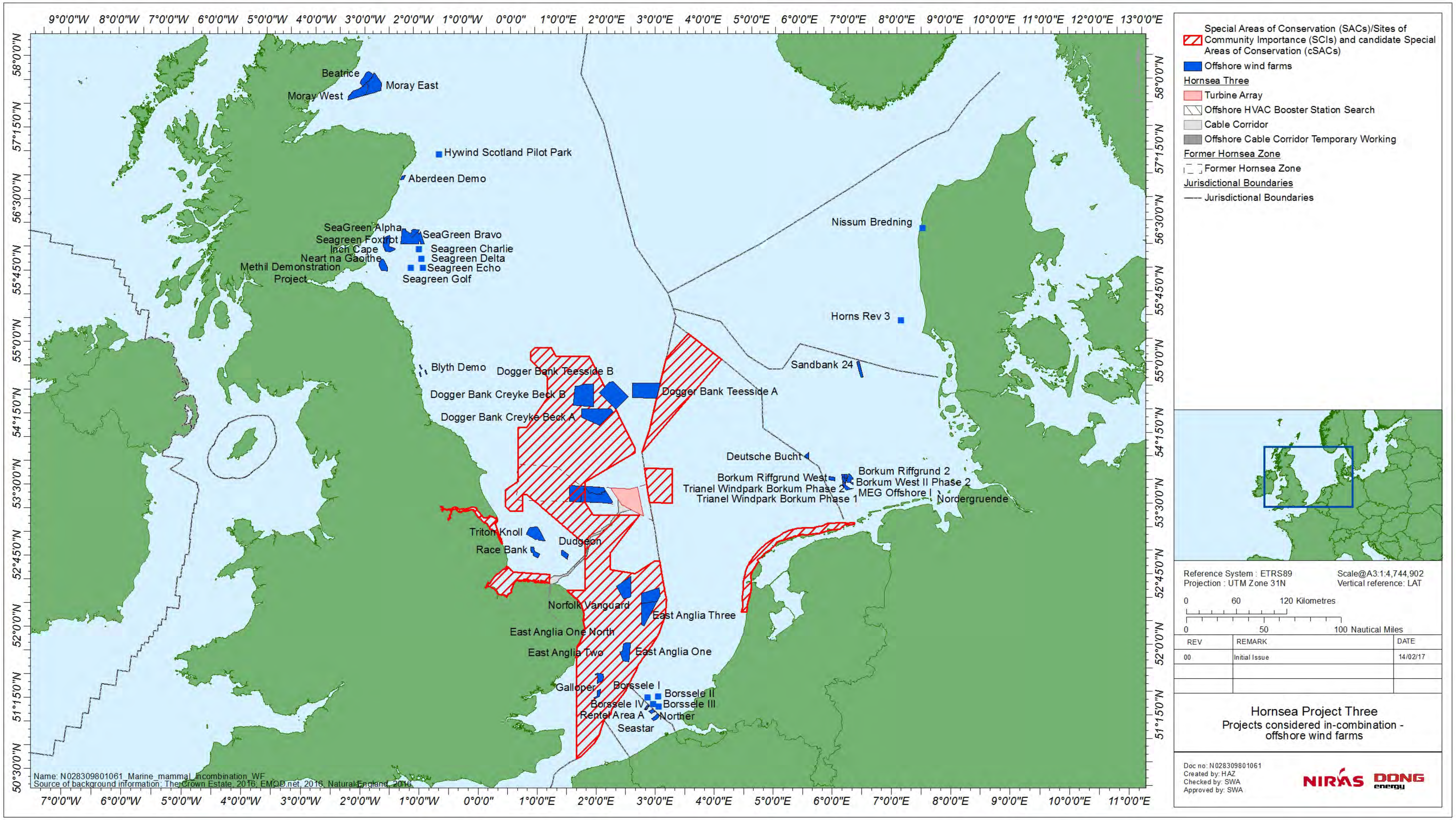

Figure 7.10: Offshore wind farms and coastal development projects screened into the marine mammal in-combination assessment.

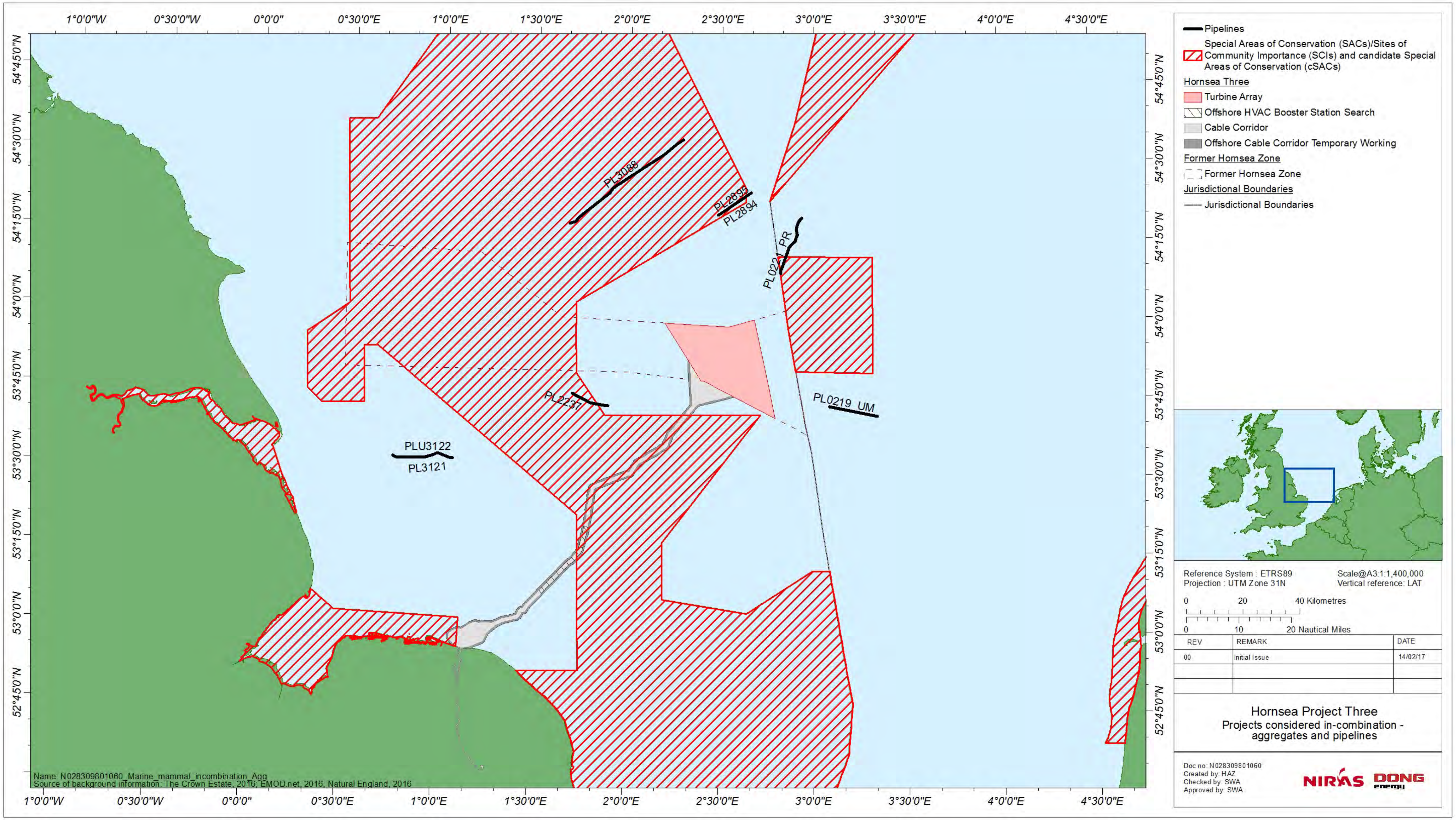

Figure 7.11: Pipelines and cables screened into the marine mammal in-combination assessment.

Table 7.24: 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/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; • 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* • Norfolk Vanguard; MORL Western Development Area.	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 apart from the Viking Interconnector • Ports and harbour projects including: Yorkshire Harbour and Marina, Chatham Maritime Marina (two projects). *Tier 2* • Norfolk Vanguard, MORL Western Development Area; 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.

7.7 Assessment of potential adverse effect on site integrity in-combination with other plans and projects

7.7.1.1 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.

7.7.2 Underwater noise

7.7.2.1 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 7.23 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 7.25).

7.7.2.2 Table 7.25 indicates that the maximum design temporal scenario for potential in combination impact of increased underwater noise due to piling is 16 years (the total duration of piling for all projects screened into the CEA (i.e. including projects that are before HOW03 but screened in as not yet built/part of the baseline)), with a gap of six years where currently no piling is predicted to occur (Table 7.25). Up to 36 offshore wind farm projects are planned to be constructed which have the potential to have an in-combination impact along with Hornsea Three, 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 five projects are currently predicted to have a directly overlapping piling period with Hornsea Three (Aberdeen Bay, Dogger Bank Creyke A & B, Dogger Bank Teesside A & B, East Anglia Three, and MORL Eastern Development Area), in Tier 2, only two projects have direct overlap of piling phases (Moray West and Norfolk Vanguard). No Tier 3 projects have been identified.

7.7.2.3 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 5.2). 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.

7.7.2.4 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 7.25 suggests that there may be an overlap in the timing of piling of up to eight offshore projects with the Hornsea Three piling phase, construction timescales are indicative and subject to change and it is considered highly likely that potential overlap of piling phases will vary from those presented above.

7.7.2.5 Piling at Hornsea Three is likely to occur in two short phases (approximately a year and a half) within the eleven year offshore construction period, with a maximum duration of six years between phases where no piling will occur (Table 7.25). 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.

7.7.2.6 Though piling is planned for construction of Convoys Warf, Inch Cape, Neart Na Gaoithe and Seagreen Alpha and Bravo, construction timelines are currently unknown and therefore these projects have not been quantitatively assessed in this in-combination assessment.

7.7.2.7 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 7.25: 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	Aberdeen Bay Demonstrator																	
	Blyth Demo																	
	Beatrice																	
	Borkum Riffgrund 2 (Germany)																	
	Borssele 1 and 2 (Netherlands)																	
	Borssele 3 and 4 (Netherlands)																	
	Deutsche Bucht Offshore Wind Farm (Germany)																	
	Dogger Bank Creyke Beck A and B																	
	Dogger Bank Teeside A and B																	
	Dudgeon	commissioned by 2017																
	East Anglia Three																	
	East Anglia One																	
	Galloper																	
	Hornsea Project One																	
	Hornsea Project Two																	
	Horns Rev 3 (Denmark)																	
	Hywind Scotland Pilot Park																	
	Inch Cape	Unknown																
	Kincardine																	
	MEG Offshore (now Merkur offshore windfarm)																	
	Moray East																	
	Nearte Na Gaoithe	Unknown																
	Nissum Bredning (Denmark)																	
	Nordergruende																	
	Norther (Belgium)																	
	Rentel Area A (Belgium)																	

Tier	Project	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033 to 2038
	Sandbank 24																	
	Seagreen Alpha	Unknown																
	Seagreen Bravo	Unknown																
	Seastar (Belgium)																	
	Trianel Windpark Borkum (Germany																	
	Triton Knoll																	
	Chatham Maritime Marina and extension																	
	Convoys Wharf	Unknown																
2	Moray West																	
2	Norfolk Vanguard																	

Harbour porpoise and pinniped lethality/auditory injury

Tier 1

7.7.2.8 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.

Injury (PTS)

7.7.2.9 The potential distances at which auditory injury (PTS) could occur in marine mammals during concurrent pile-driving at Hornsea Three are very small (Table 7.10). At 15% hammer blow energy, for most scenarios, the potential for auditory injury falls within the standard 500 m mitigation range recommended in the draft JNCC guidelines (2010) (Table 7.10). The exception to this is for harbour porpoise, where soft start could commence at 750 kJ (for the 5,000 kJ) hammer, in which case the potential injury range was estimated out to 1,500 m and therefore this is the distance over which mitigation will be carried out to reduce the risk of injury to all marine mammals (Table 7.12). Assuming that mitigation is implemented as set out in the MMMP (marine mammal mitigation plan), which may include use of marine mammal observers and ADDs, the risk of auditory injury (PTS) will be reduced 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 considered within this in-combination assessment are likely to be smaller than for Hornsea Three.

Tier 2

7.7.2.10 Impacts of Tier 2 projects will not be greater than Tier 1 projects.

7.7.2.11 Hornsea Three will adhere to a MMMP to reduce the potential risk of auditory injury (PTS), therefore no further assessment for potential cumulative impact of auditory injury has been carried out.

Pinniped – Disturbance: TTS/Fleeing (displacement)

7.7.2.12 As discussed with in 7.5.2.22 in the absence of defined criteria for behavioural effects for pinnipeds in Southall *et al*. (2007) the criterion most commonly used for behavioural disturbance is the same as for onset of TTS/fleeing (Table 7.10). This would be considered to be at the upper end of the behavioural scale as it is assumed that animals subjected to noise levels that elicit TTS/fleeing would be displaced from the affected area. It has therefore not been possible to present results for lower level behavioural effects, such as likely or possible avoidance, for pinnipeds.

Tier 1

7.7.2.13 The maximum range over which TTS/fleeing was estimated to occur in seals due to concurrent piling using 5,000 kJ hammer energy at Hornsea Three is 1 km, with a total potential area affected of 6.28 km^2 (Table 7.15).

7.7.2.14 Most other project Environmental Statements also use the Southall *et al.* (2007) criteria for TTS/fleeing to predict the range over which behavioural effects could occur. The exception to this was Moray East which used the Nedwell *et al.* (2007b) dBht approach to predict behavioural ranges and therefore these are not directly comparable with the TTS/fleeing ranges.

7.7.2.15 It is not considered appropriate or realistic to add modelled areas over which potential behavioural effects could occur, as there is likely to be a great deal of variation in timing, duration, and hammer energy used throughout the various in-combination project construction periods detailed above. It is however assumed, as a precautionary approach, that animals within the TTS/fleeing zone will be displaced from the impacted area. During periods of displacement alternative foraging areas will be available to seals throughout the reference MU area.

7.7.2.16 The in-combination impact of behavioural effects on seals is predicted to affect animals directly (behavioural responses) and indirectly (limiting availability of foraging areas). Due to small ranges of effects in the context of the wider available habitat (i.e. area of SEE MU for harbour seal is 73,790 km^2 and area of SEE + NEE MU for grey seal is 122,508 km^2) the in-combination assessment is of no greater magnitude than for Hornsea Three alone.

7.7.2.17 The potential impact ranges for behavioural effects (TTS/fleeing) in seals during piling at projects considered within this in-combination assessment are very small and are not considered likely to contribute cumulatively to an increased sensitivity in seals as the increase in the proportion of the MU reference populations affected cumulatively would be marginal. Cumulative sensitivity to behavioural effects due to piling from projects identified as having a potential in-combination impact within the associated reference MU for grey and harbour seals is therefore likely to be the same as for Hornsea Three concurrent piling alone.

Tier 2

7.7.2.18 The potential impact ranges for disturbance of seals during piling at Tier 2 projects are very small and are not considered likely to contribute cumulatively to an increased sensitivity in these species. In combination potential for disturbance due to piling from projects within the associated reference MU for grey and harbour seals is therefore likely to be the same as for Hornsea Three concurrent piling alone and impacts of Tier 2 projects will not be greater than Tier 1 projects.

Conclusions

The Wash and North Norfolk Coast SAC

7.7.2.19 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

7.7.2.20 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 (lethality and injury only – behavioural effects assessed separately)

7.7.2.21 Based on the information presented above, there is no indication that the potential for in-combination lethality/ 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.

7.7.2.22 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 (lethality and injury only for harbour porpoise)

7.7.2.23 Based on the information presented above, there is no indication that the potential for lethality/ injury and hearing impairment or behavioural effects associated with underwater noise on the harbour and grey seal features or for lethality/ 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

7.7.2.24 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

7.7.2.25 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

7.7.2.26 Within Tier 1, only five projects are currently predicted to have a directly overlapping piling period with Hornsea Three (Aberdeen Bay, Dogger Bank Creyke A & B, Dogger Bank Teesside A & B, East Anglia Three, and MORL Eastern Development Area), in Tier 2, only two projects have direct overlap of piling phases (MORL Western Development Area and Norfolk Vanguard). No Tier 3 projects have been identified (PEIR Volume 2 Chapter 4). Aberdeen Bay, MORL Eastern Development Area and MORL Western Development Area lie more than 26 km from the Southern North Sea cSAC and, therefore, have not been considered further.

7.7.2.27 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.

7.7.2.28 The spatial extent of disturbance is presented for sequential and concurrent piling schedules, providing the range of in-combination effects (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.

7.7.2.29 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.

Table 7.26: 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
Tier 1		
Hornsea Three	Max: 2145.9 Min: 362.1	Max: 8.00 Min: 1.30
Dogger bank Creyke A & B	Max: 4245.3 Min: 2610.2	Max: 15.71 Min: 9.66
Dogger bank Teesside A & B	Max: 1525.4 Min: 129.3	Max: 5.56 Min: 0.48
East Anglia Three	Max: 2123.7 Min: 1546.4	Max: 7.86 Min: 5.72
Total for Tier 1	*Max: 10040.3* *Min: 5010.1*	*Max: 37.13* *Min: 17.16*
Tier 2		
Norfolk Vanguard	Max: 2123.7 Min: 1345.35	Max: 7.86 Min: 4.98

Table 7.27: 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
Tier 1		
Hornsea Three	Max: 2223.6 Min: 351.2	Max: 8.23 Min: 1.30
Dogger bank Creyke A & B	Max: 5367 Min: 2663.9	Max: 19.86 Min: 9.86
Dogger bank Teesside A & B	Max: 2073.9 Min: 147.9	Max: 7.68 Min: 0.55
East Anglia Three	Max: 3025.7 Min: 1577	Max: 11.20 Min: 5.84
Total for Tier 1	*Max: 12690.2* *Min: 4740*	*Max: 46.97* *Min: 18.85*
Tier 2		
Norfolk Vanguard	Max: 3891.73 Min: 1345.35	Max: 14.41 Min: 4.98

Table 7.28: In-combination spatial effect range (sequential piling) for the Southern North Sea cSAC winter component

Project	Overlap of winter cSAC (km²)	% of winter cSAC
Tier 1		
Hornsea Three	Max: 92.6 Min: 0	Max: 0.73 Min: 0
East Anglia Three	Max: 1827.35 Min: 288.4	Max: 14.4 Min: 2.27
Total for Tier 1	*Max: 1919.95* *Min: 288.4*	*Max: 15.13* *Min: 2.27*
Tier 2		
Norfolk Vanguard	Max: 1081.35 Min: 288.4	Max: 8.52 Min: 0.002

Table 7.29: In-combination spatial effect range (concurrent piling) for the Southern North Sea cSAC winter component

Project	Overlap of winter cSAC (km²)	% of winter cSAC
Tier 1		
Hornsea Three	Max: 92.6 Min: 0	Max: 0.73 Min: 0
East Anglia Three	Max: 1981.96 Min: 288.4	Max: 15.62 Min: 2.27
Total for Tier 1	*Max: 2074.56* *Min: 288.4*	*Max: 16.35* *Min: 2.27*
Tier 2		
Norfolk Vanguard	Max: 1461.83 Min: 0.28	Max: 11.52 Min: 0.002

Tier 1

7.7.2.30 Table 7.26 and Table 7.27 identify that for Tier 1 projects the maximum combined spatial 'one off' overlap with the summer component of the cSAC is 37.13% based on the worst case of sequential piling and 46.97% based on the worst case of concurrent piling.

7.7.2.31 Table 7.28 and Table 7.29 identify that the maximum combined spatial 'one off' overlap with the winter component of the cSAC is 15.13% based on the worst case of sequential piling and 16.35% based on the worst case of concurrent piling, which does not exceed the 20% threshold.

7.7.2.32 The minimum combined spatial 'one off' overlap with the summer component of the cSAC is 17.16% for sequential piling and 18.85% for concurrent piling, which would only occur if all project piling in their best (minimum cSAC overlap) locations. The minimum combined spatial 'one off' overlap with the winter component of the cSAC is 2.27%. It is, therefore, likely that the actual overlap would be somewhere between the maximum and minimum values. Neither the minimum spatial overlap for the cSAC summer component or winter component exceed the 20% threshold.

7.7.2.33 There is likely to be a great variation in timing, duration and hammer energy used throughout the various project construction periods. Such a combined maximum extent of disturbance would only occur if all the activities listed under Tier 1 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.

7.7.2.34 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 1 project locations, as the maximum design scenario assumes that all the animals disturbed could potentially be displaced during piling activity at each location. The in-combination assessment uses each projects' maximum design scenario, and therefore is inherently conservative

Conclusions

7.7.2.35 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, all projects obtaining CfD's and enough installation vessel 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.

7.7.2.36 Further assessment of the in-combination behavioural effect on the Southern North Sea cSAC will be undertaken considering these assumptions in more detail, which will affect the extent of the impact.

Tier 2

7.7.2.37 The addition of the tier 2 project will increase the percentage overlap of the Southern North Sea cSAC. In Tier 2, only one project (Norfolk Vanguard) has the potential to overlap with the southern North Sea cSAC summer component, with a maximum of 7.86 - 14.41% and a minimum overlap of 4.98%. The inclusion of Norfolk Vanguard would increase the percentage overlap of the cSAC winter component by a maximum of 8.52 -11.52% and a minimum of 0.002%. The average effect over the season (summer or winter) would be less than the maximum spatial overlap. There is doubt as to whether Tier 2 projects will achieve consent and considerable further doubt as to their final form and the timescale over which they may actually come forward.

Conclusions

7.7.2.38 As for Tier 1, a number of precautionary assumptions have been made while undertaking this assessment. Further assessment of the in-combination behavioural effect on the Southern North Sea cSAC will be undertaken, considering these assumptions in more details, which will affect the extent of the impact.

7.7.3 Increased vessel traffic

7.7.3.1 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 7.1) during construction, operation or decommissioning of other projects.

7.7.3.2 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.

7.7.3.3 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.

7.7.3.4 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 (PEIR volume 4, annex 3.1: Subsea Noise Technical Report).

7.7.3.5 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.

7.7.3.6 For harbour porpoise, projects, plans and activities have been considered within the North Sea MU area (Figure 7.5); 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 7.7).

7.7.3.7 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

7.7.3.8 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.

7.7.3.9 Thirteen offshore pipeline and cable projects and two coastal projects have been scoped into this in-combination assessment (Table 7.30). 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.

7.7.3.10 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.

7.7.3.11 Table 7.30 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 11,776 over the construction period (two phases over 11 years with up to six years between phases).

7.7.3.12 It has been assumed that at worst a similar uplift would occur in vessel numbers over for the decommissioning period. A total uplift of 2,832 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 array area. Therefore, for Hornsea Three alone vessel movements are likely to be an overestimate.

7.7.3.13 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.

7.7.3.14 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 7.30: 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	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

7.7.3.15 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.

7.7.3.16 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).

7.7.3.17 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). 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 Tier 1 projects.

7.7.3.18 The impact is therefore predicted to be of regional spatial extent, long term duration (lifetime of the project – 25 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).

<u>Conclusions</u>

The Wash and North Norfolk Coast SAC

7.7.3.19 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

7.7.3.20 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

7.7.3.21 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

7.7.3.22 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

7.7.3.23 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

7.7.3.24 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.

7.8 Summary

7.8.1.1 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.

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 the sites Conservation Objectives.

7.8.1.3 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.

7.8.1.4 On this basis, there is no indication of an adverse effect on any of the any of the designated sites listed above.

7.8.1.5 These conclusions are summarised in Table 7.31below.

Table 7.31: 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 • 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 from foundation installation • 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 • 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 • 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 • 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
Southern North Sea cSAC	• Harbour porpoise	Construction/Decommissioning	• Underwater noise	An adverse effect on site integrity is not anticipated	Further assessment of the in-combination effects required
			• 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

8. Assessment of Adverse Effects on Integrity: offshore ornithology

8.1 Introduction

8.1.1.1 The screening exercise (stage 1 of the HRA process) identified potential for LSEs on the offshore ornithological features of the sites listed in Table 8.1 and shown in Figure 8.1.

8.1.1.2 This Draft 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.

8.1.1.3 The screening report followed Natural England's guidance note regarding screening for SPA features in the non-breeding season (Natural England, 2013). This approach defined Biologically Defined Minimum Population Scales (BDMPS) for each species outside of the breeding season.

8.1.1.4 The final assessment for each effect is based upon expert judgement.

8.2 Conservation Objectives

8.2.1.1 The draft 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.*

8.3 Potential impacts

8.3.1.1 The screening exercise identified the potential for LSEs on offshore bird features in relation to the impacts detailed in Table 8.1. The potential impacts form Hornsea Three on offshore ornithological features are detailed in Table 8.2.

Table 8.1: 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
Flamborough and Filey Coast 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
	• Herring gull (non-breeding season)	Operation	Collision risk
	• Puffin (breeding and non-breeding seasons)	Construction/ decommissioning	Disturbance
		Operation	Displacement
	• Guillemot (non-breeding season)	Construction/ decommissioning	Disturbance
		Operation	Displacement
	• Razorbill (non-breeding season)	Construction/ decommissioning	Disturbance
		Operation	Displacement

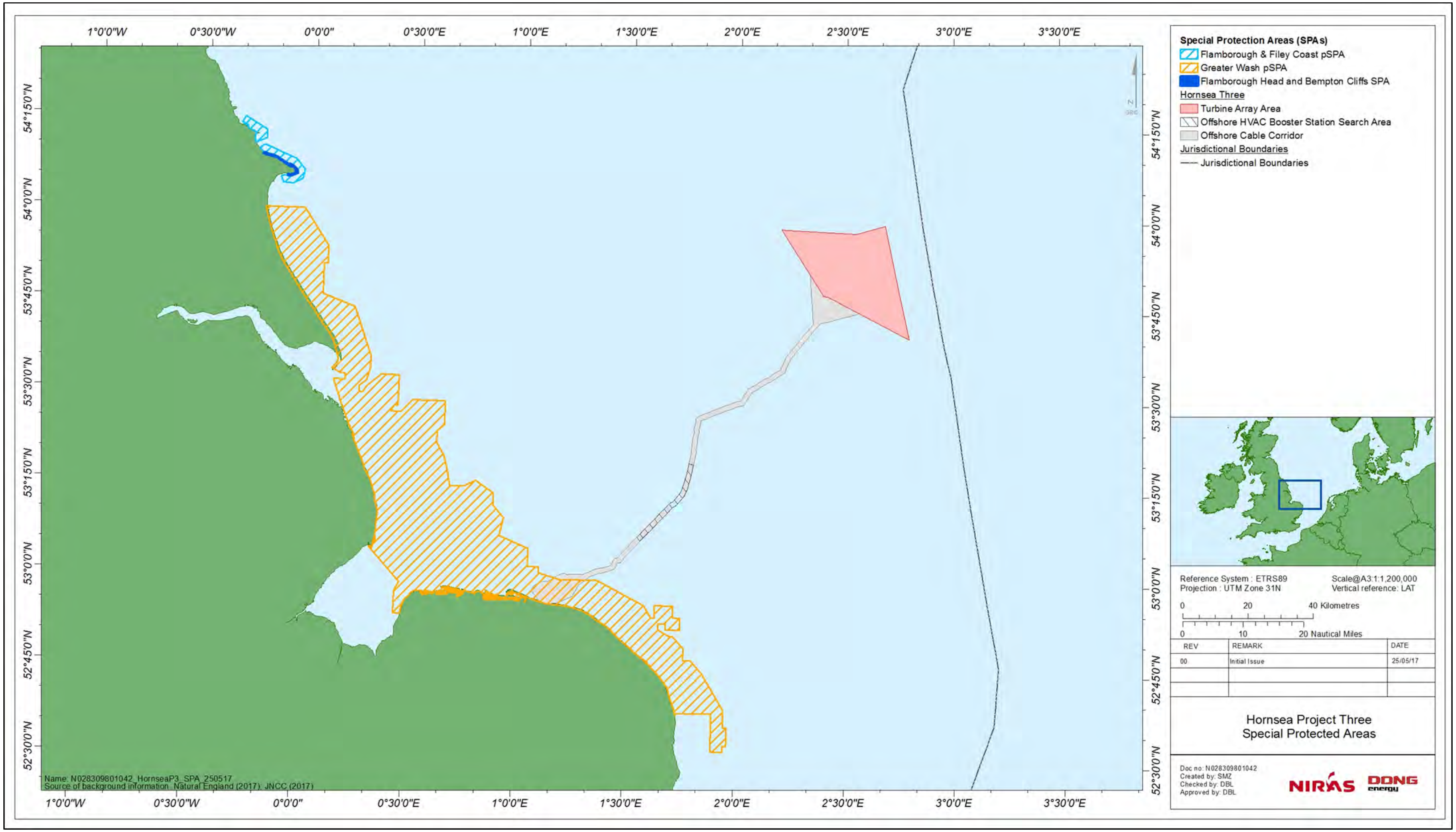

Figure 8.1: Sites with offshore bird features identified for AA.

Table 8.2: 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.
	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/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.
	Displacement	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	

8.4 Baseline information

8.4.1 Evidence-based approach

8.4.1.1 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 Draft Evidence Plan (DONG Energy 2017, Annex 2), the purpose of which is to agree the information Hornsea Three needs to supply to the PINS, as part of a DCO application for Hornsea Three. This includes agreeing as to the methodology to inform the baseline. The Evidence Plan seeks to ensure compliance with the EIA and Habitat Regulations Assessment (HRA).

8.4.1.2 As part of the Evidence Plan process, an Offshore Ornithology EWG was established with representatives from the key regulatory bodies, statutory nature conservation bodies (SNCBs) and non-statutory parties, including the MMO, Natural England and The Royal Society for the Protection of Birds (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 into 2017.

8.4.1.3 The approach proposed by Hornsea Three 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. 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 to be reviewed by the EWG (further detailed in a section below).

8.4.1.4 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 8.4.4 below). The survey methodologies have been discussed with the Expert Working Group (EWG) through the Evidence Plan process and supplemented by existing data, have been agreed as appropriate to enable the characterisation of the baseline environment. The EWG have agreed that monthly aerial surveys from April 2016 – September 2017, considering the timescales of the Project, is the most appropriate approach to providing enough site specific data to characterise the baseline environment.

8.4.1.5 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, and 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 2016). 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.

8.4.2 Identification of SPAs relevant to Hornsea Three

8.4.2.1 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 an 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 Flamborough and Filey Coast (Filey and Flamborough) pSPA.

8.4.2.2 For the identification of SPAs relevant to Hornsea Three, mean-maximum foraging ranges 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).

8.4.2.3 During the non-breeding period, birds from colonies further afield may also be present within Hornsea Three, 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 across colonies from within the region are given in the supporting documents associated with the Draft Report to Inform Appropriate Assessment for Hornsea Three.

8.4.3 Desktop study

8.4.3.1 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 8.3.

Table 8.3: Summary of key desktop reports.

Title	Source	Year	Author
A review of assessment methodologies for offshore wind farms	COWRIE	2009	Maclean *et al,*
British Trust for Ornithology (BTO) online profiles of birds occurring in Britain and Ireland, BirdFacts	BTO	2016	Robinson
Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Ares	*Biological Conservation*	2012	Thaxter *et al.*
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, 2009b	Multiple	The Crown Estate
Atlas of seabird distribution in northwest European waters	JNCC	1995	Stone *et al.*
JNCC Online SPA standard data forms for Natura 2000 sites	http://jncc.defra.gov.uk/page-1400	Multiple	
Biologically appropriate, species-specific, geographically non-breeding season population estimates for seabirds	Natural England	2015	Furness
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.*
The Migration Atlas	British Trust for Ornithology	2002	Wernham *et al.*
Population estimates of birds in Great Britain and the UK	British Birds	2013	Musgrove *et al.*
Wetland Bird Survey (WeBS) Annual Reports and Report Online interface	WeBS Partnership	Multiple	Multiple
Assessing the risk of offshore wind farm development to migratory birds designated as features of UK SPAs	SOSS	2012	Wright *et al.*
Existing offshore wind farm Environmental Statements and Monitoring Reports	Multiple	Multiple	Multiple
Survey data relating to the former Hornsea Zone, including Hornsea Project One and Hornsea Project Two boat based surveys	SMart Wind	2010-2013	
Reports, guidance and advice notes	Scoping Response from Natural England	Multiple	Multiple

8.4.4 Site specific surveys

Site-specific aerial surveys

8.4.4.1 For Hornsea Three, digital aerial surveys have also been undertaken monthly since April 2016. 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 PEIR Annex 5.1: Baseline Characterisation Report, respectively. The aerial survey programme for Hornsea Three is not yet complete with only data from April 2016 to February 2017 currently incorporated into the assessments in this Draft Report to Inform Appropriate Assessment.

8.4.4.2 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 PEIR Annex 5.1: Baseline Characterisation Report.

8.4.4.3 It was agreed through the Offshore Ornithology EWG that surveys of the cable corridor were not required.

Former Hornsea Zone Boat-based surveys

8.4.4.4 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.

8.4.4.5 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

8.4.4.6 As part of the preparation of data for use in the PEIR and Draft 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.

8.4.4.7 This analysis will attempt is intended to produce the following outputs:

- Calculate seasonal density estimates for the Hornsea Three area (plus relevant buffers) for key species and seasons;
- Identify the seasonal and annual variability in population density for key species for each analysis area;
- Investigate suitable co-variates (such as sea temperature, bathymetry, distance from shore, chlorophyll a) that might explain observed variability in densities and flight heights; and
- Undertake detailed analysis including statistical analysis and, where possible, predictive modelling.

8.4.4.8 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:

- Identify the extent of boat-based ornithological records across the Hornsea Three area;
- Characterise uncertainty in population estimates and density distribution;
- Compare population estimates for 10 key species for Hornsea Three with those derived for the Hornsea Project One and Hornsea Project Two sites;
- Analyse the variability in patterns of observed flight heights across the former Hornsea Zone by season and year;
- Compare results of the boat-based and aerial surveys;
- Discuss implications of the above for collision risk modelling and displacement analysis; and
- Reference other potential sources of information for the population estimates and density distributions.

8.4.4.9 The results of the meta-analysis are not yet available for incorporation into the Hornsea Three Draft Report to Inform Appropriate Assessment however. it is expected that these will be presented to and discussed with the Expert Working Group (EWG) and will be incorporated into the final application. Therefore the eleven months of site-specific digital aerial data collected for Hornsea Three is considered to be the appropriate baseline for use in this assessment.

8.4.5 Displacement analysis

8.4.5.1 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.

8.4.5.2 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.

8.4.5.3 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 Statutory Nature Conservation Bodies (SNCBs) (JNCC *et al*., 2017).

8.4.5.4 The full process applied to identify species that may be impacted by displacement effects is documented in the Baseline Characterisation Report (PEIR Annex 5.1: Offshore Ornithology Baseline Characterisation Report).

8.4.5.5 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.

8.4.5.6 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 its advisors as being unrealistic and over-precautionary.

8.4.5.7 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 as applicable (e.g. ‘breeding’, ‘post-breeding’, ‘non-breeding’ and ‘pre-breeding’) in Annex 5.2: Analysis of displacement impacts on seabirds. The matrices and assessments presented in this chapter 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.

8.4.5.8 The predicted intensity of displacement for each species is based on available published evidence (e.g., Krijgsveld *et al*., 2011; Vanermen *et al*., 2013) and published reviews of species vulnerability to the effect (e.g. Wade *et al*. 2016).

8.4.5.9 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 most 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.

8.4.5.10 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 Resolution construction vessel while piling was in progress (RPS, 2012). Similarly, Vanermen *et al*. (2013) in their study of Belgian offshore wind farms, noted that initially, 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.

8.4.5.11 Based on evidence in the literature, such as that in the preceding discussion (e.g. Krijgsveld *et al.*, 2011; RPS, 2012; Vanermen *et al.*, 2013), it was considered that the species with low vulnerability to disturbance/ displacement impacts or with a relatively low macro avoidance rate (skuas, gulls and terns) could be screened out of further assessment from all phases of the project.

8.4.5.12 For those species selected for displacement analysis, although a range of values are presented within each matrix table (0-100%); a single level of displacement is selected within the table to take forward for the purposes of assessment. This level is species-specific and considered suitably conservative and representative of evidence where available.

8.4.5.13 With regards to those species screened into this assessment, Krijgsveld *et al* . (2011) identifies fulmar as a lower sensitivity species with a displacement rate of 28%, and gannet and auks as higher sensitivity species with displacement rates of 64% and 68% respectively. For razorbill further information on displacement is presented in Walls *et al.* (2013) which presents information from monitoring at Robin Rigg Offshore Wind Farm. This suggests a displacement rate of 30% for auk species and on a precautionary basis, incorporating the information from Krijgsveld *et al.* (2011) and Walls *et al.* (2013), 40% is used for the assessment of displacement for razorbill at Hornsea Three (Table 8.4) For fulmar and gannet, precautionary displacement rates of 30% and 70% are used, respectively (Table 8.4). Cook *et al.* (2014) provides additional evidence for gannet displacement rates stating a macro-avoidance of 64%.

8.4.5.14 In addition to the proportion of birds displaced within a particular area, a second aspect to consider is the spatial distribution of birds. JNCC *et al*. (2017) interim guidance recommends that for the species of highest sensitivity (divers and sea ducks), the site 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 of impact of displacement level should be applied to the buffer zone, as there is not sufficient evidence to underpin any such gradient application on a species-by-species basis. This is a precautionary approach that doesn't represent the reality of some degree of gradient with respect to how close individual birds will approach a source of disturbance influenced by e.g. past exposure to the event (habituation), need to feed chicks and ability to forage as successfully elsewhere.

8.4.5.15 Buffers taken forward to impact assessment for Hornsea Project Three are the wind farm plus a 2 km buffer for all species, with no gradient of impact of displacement level applied to the buffer zone. This is because species deemed particularly sensitive to displacement, such as divers and seaduck did not qualify as Valued Ornithological Receptors (VORs) in this assessment for Hornsea Three array area on being absent (e.g. common scoter) or recorded in very small numbers (e.g. red-throated diver) by site-specific aerial surveys (Annex 5.1: Baseline Characterisation Report). Where red-throated diver and common scoter did qualify as Valued Ornithological Receptors (VORs) in this assessment for Hornsea Three, namely the Hornsea Three Export Cable Route, Hornsea Three offshore cable corridor is still considered to be an equally valid approach to apply when considering disturbance / displacement due to low densities of birds and nature of the potential impacts..

8.4.5.16 In order to assess the displacement effect, the seasonal mean peak population of birds recorded within Hornsea Three offshore cable corridor plus a 2km buffer is considered sufficiently precautionary for the realistic worst-case in line with guidance (JNCC *et al*., 2017).

8.4.5.17 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, any 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.

8.4.5.18 There are no directly applicable 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.

8.4.5.19 There is little or no evidence on what the extent of the impact magnitude may be, although a typical ceiling of 10% is often applied by advisors. 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. The mortality rate varies between species, with actual assigned values dependent on that species' known behaviour (e.g. habitat and foraging flexibility). These rates are considered suitably precautionary for EIA requirements, although the matrices presented show rates of up to 100% for both displacement and mortality as recommended in interim guidance JNCC *et al*., 2017).

Table 8.4: Assessment criteria for displacement effects for the area Hornsea Three array area plus a 2 km buffer

Species	Season of relevance	Months	Displacement rate (%)	Mortality rate (%)
Fulmar	Breeding	Apr – Aug	30	2
	Post-breeding	Sep-Oct	30	1
	Non-breeding	Dec	30	1
	Pre-breeding	Jan – Mar	30	1
Gannet	Breeding	Apr – Aug	70	2
	Post-breeding	Sep – Nov	70	1
	Pre-breeding	Dec- Mar	70	1
Puffin	Breeding	Apr – Jul	40	10
	Non-breeding	Aug – Mar	40	1
Razorbill	Breeding	Apr – Jul	40	10
	Post-breeding	Sep – Oct	40	2
	Non-breeding	Nov – Dec	40	1
	Pre-breeding	Jan – Mar	40	2
Guillemot	Breeding	Mar – Jul	30	10
	Non-breeding	Aug – Feb	30	1

8.4.5.20 During the 'non-breeding' periods (i.e., defined here as all seasons outside of breeding), seabirds are generally less constrained to restricted foraging ranges, free from providing food for young or breeding partners, and are more capable of relocating to other areas. 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 as individuals are not constrained by central place foraging from a colony and have a greater degree of flexibility in utilising different resources. Therefore a mortality rate of 1% of displaced birds has been adopted and is considered precautionary.

8.4.5.21 '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, 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 razorbill due to the ongoing care required for young, as well as any stress incurred during the moult period when foraging range is more limited.

8.4.6 Collision Risk Modelling

8.4.6.1 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).

8.4.6.2 Masden (2015) presents an update to the 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 evaluation of the Masden (2015) variant of the collision risk model is required. As a result, Masden (2015) has not been used to calculate collision risk estimates for the PEI stage of Hornsea Three. Pending this review and any subsequent modification, the use of Masden (2015) will be considered as part of the final EIA for Hornsea Three.

8.4.6.3 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."*

8.4.6.4 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).

8.4.6.5 The aerial survey programme for Hornsea Three is not yet complete with only data from April 2016 to February 2017 currently incorporated into the collision risk modelling supporting the assessments in this Draft Report to Inform Appropriate Assessment. As such, the baseline characterisation for the site is only partially complete serving as an interim measure to inform the PEI and will be updated for the final DCO application following the completion of aerial surveys at Hornsea Three. For the purposes of this preliminary assessment, it is considered that model predictions provide an approximate indication of the likely risk. The use of an incomplete data set has implications for the calculation of the proportion of birds at rotor height at Hornsea Three not least a limited flight height dataset. Therefore at this stage only Options 2 and 3 of the Band (2012) CRM, which use generic flight height information (from Johnston *et al*., 2014) have been used to calculate collision risk estimates.

8.4.6.6 A full description of the collision risk modelling methodology is provided in PEIR Annex 5.3: Collision Risk Modelling.

8.4.6.7 The worst case scenario for collision risk in this modelling process is taken to be the development scenario comprising the maximum number of turbines - 342 with parameters as defined in volume 1, chapter 3: Project Description. The parameters for this scenario are presented in Annex 5.3: Collision Risk Modelling. A wind turbine hub-height of 127.47 m (above LAT) will be used at Hornsea Three. This provides for a lower tip height clearance of 34.97 m LAT reducing the potential collision risk impacts on birds. The lower tip height clearance is consistent with the consented value at Hornsea Project Two.

8.4.6.8 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.

Regularly occurring seabirds

8.4.6.9 Collision risk modelling was conducted for four regularly occurring seabird species at Hornsea Three including gannet and kittiwake that have been screened in for AA.

8.4.6.10 Collision risk modelling for these species has been conducted using the Band (2012) CRM Bird biometric parameters and densities from Hornsea Three for each of these species is presented in Annex 5.3 to the PEIR: Collision Risk Modelling.

8.4.6.11 The avoidance rates applied for each species are also presented in Annex 5.3: Collision Risk Modelling. The rates applied are taken from Cook *et al*. (2014) which presents avoidance rates for all four species included in the modelling for Hornsea Three. Cook *et al*. (2014) recommended avoidance rates for use with the Basic model for all four species and with the Extended model for lesser black-backed gull and great black-backed gull. Cook *et al.* (2014) were unable to recommend an avoidance rate for use in the Extended model for gannet and kittiwake and as such a default 98% avoidance rate is applied in the modelling conducted for Hornsea Three.

8.4.6.12 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 8.5 taking into account the recommendations in Cook *et al*. (2014) and JNCC *et al*. (2014).

Table 8.5: Avoidance rates applied in collision risk modelling for regularly occurring seabirds at Hornsea Three.

Band (2012) model	Gannet	Kittiwake	Lesser black-backed gull	Great black-backed gull
Basic	98.9 (±0.2)	98.9 (±0.2) 99.2 (±0.2)	99.5 (±0.1)	99.5 (±0.1)
Extended	98.0	98.0	98.9 (±0.2)	98.9 (±0.2)

8.4.6.13 Outputs from the collision risk modelling undertaken gannet and kittiwake are presented in PEIR Annex 5.3: Collision Risk Modelling.

8.4.6.14 Ongoing research is currently investigating the avoidance behaviour of seabirds at offshore wind farms (the Offshore Renewables Joint Industry Programme), with any information that becomes available during the programme for Hornsea Three to be incorporated into the generic empirical evidence base for avoidance rates, if considered appropriate.

8.4.7 Baseline Information

8.4.7.1 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 PEIR Annex 5.1: Baseline Characterisation Report.

Species accounts

8.4.7.2 The following species accounts summarise information on the identified bird features to be considered within the AA.

Common scoter

8.4.7.3 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).

8.4.7.4 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.

Red-throated diver

8.4.7.5 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 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).

8.4.7.6 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.

8.4.7.7 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). Higher densities of birds within the Greater Wash pSPA occur close inshore, 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).

Gannet

8.4.7.8 Gannet is a widely dispersed species 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 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).

8.4.7.9 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 Filey and Flamborough pSPA (Balmer *et al*., 2013). This colony was estimated at 7,859 nests in 2009 (SMP, 2017) and increased to an estimated 9,947 pairs in 2011, 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.

8.4.7.10 Gannet is listed as a qualifying interest species in the breeding season for five SPAs 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 Flamborough and Filey Coast 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.

Puffin

8.4.7.11 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).

8.4.7.12 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).

8.4.7.13 Data from the 2004 to 2008 reports, Aerial Surveys of Waterbirds in the UK (DECC, 2009), show that no puffins were recorded during aerial surveys of the Greater Wash survey blocks GW2, GW9 and GW10. Birds recorded as 'auk spp.' were recorded, however, with a means of 693 and 722 in March and May respectively. Numbers were lower throughout the rest of the year, but this was still one of the most frequently recorded species groups during aerial surveys.

8.4.7.14 Puffin is listed as a qualifying interest species in the breeding season for 11 SPAs on the UK east coast. The distance between Hornsea Three and the nearest designated site (Filey and Flamborough pSPA) is within the maximum foraging range of puffin (200 km) (Thaxter *et al*., 2012). Puffin is a non-listed assemblage feature at Filey and Flamborough pSPA. No other SPAs are within the mean-maximum or maximum foraging range (200 km; Thaxter *et al*., 2012) of puffin.

Razorbill

8.4.7.15 Seabird 2000 recorded 164,557 individuals at breeding colonies around Britain (Mitchell *et al*., 2004). The closest large colony to Hornsea Three is at Filey and Flamborough 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).

8.4.7.16 High densities of razorbills have been recorded in the north-western North Sea with lower densities 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).

8.4.7.17 Razorbill is listed as a qualifying interest species in the breeding season for 10 SPAs 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).

Guillemot

8.4.7.18 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).

8.4.7.19 Seabird 2000 recorded 1,322,830 individuals at breeding colonies in Britain (Mitchell *et al*., 2004). The closest large colonies to Hornsea Three are at the Farne Islands and Bempton Cliffs (including Flamborough Head).

8.4.7.20 Guillemot is listed as a qualifying interest species in the breeding season for 20 SPAs 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).

8.4.7.21 The closest colony to Hornsea Three is Filey and Flamborough pSPA which supported 41,607 pairs in 2008-12. The distance between Hornsea Three and Flamborough and Filey Coast pSPA is approximately 149 km, further than the maximum foraging range of guillemot (135 km; Thaxter *et al*., 2012).

Kittiwake

8.4.7.22 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). The nearest large colony 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.

8.4.7.23 From August to October, kittiwakes begin to disperse across the North Sea, although the predominant distribution still reflects 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 kittiwake's preference for pelagic habitats in winter.

8.4.7.24 Kittiwake is listed as a qualifying interest species in the breeding season for 20 SPAs 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).

8.4.7.25 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 Filey and Flamborough pSPA colony does however suggest that there may be connectivity between the Filey and Flamborough pSPA and Hornsea Three.

8.4.8 Data limitations

8.4.8.1 Site-specific digital aerial surveys of the Hornsea Three array area and a 4 km buffer commenced in April 2016 and are ongoing. In addition, the meta-analysis of previous boat-based bird data collected within the former Hornsea zone is being undertaken and will be discussed with the Expert Working Group (EWG) and included in the final application.. This initial assessment is, therefore, based on a partial and preliminary characterisation of the baseline environment for offshore ornithology.

8.4.8.2 It is intended that the EIA and Final Report to Inform Appropriate Assessment to be submitted with the DCO Application will include an agreed baseline characterisation, comprising aerial digital surveys supplemented and contextualised with analyses of zonal boat-based survey data.

8.4.9 Apportioning and seasonal BDMPS

8.4.9.1 The birds present within at Hornsea Three may vary in their origin depending on the biological season; the area over which these birds could originate from 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'.

8.4.9.2 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.

8.4.9.3 The apportioning values used within this assessment have been calculated following the methodologies applied 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.

8.5 Assessment of Adverse Effects on Integrity – Alone

8.5.1 Greater Wash pSPA

Site description

8.5.1.1 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 (p) SPAs 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.

8.5.1.2 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.

8.5.1.3 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.

8.5.1.4 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.

8.5.1.5 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.

8.5.1.6 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.

8.5.1.7 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).

8.5.1.8 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).

8.5.1.9 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).

8.5.1.10 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

8.5.1.11 Table 8.6 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 and common scoter, both with respect to potential disturbance during construction and displacement and potential displacement during operation.

Table 8.6: Results of screening with respect to the interest features of the Greater Wash pSPA

Feature	Project Phase	Potential Impact	Likely Significant Effect
Sandwich tern	All	All	No
Common tern	All	All	No
Little tern	All	All	No
Little gull	All	All	No
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

Red-throated diver

Construction/decommissioning

Disturbance

8.5.1.12 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.

8.5.1.13 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.

8.5.1.14 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 8.2). 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 0.51 birds/km^2 possible along the cable route.

8.5.1.15 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.

8.5.1.16 The density of red-throated diver within the export cable route plus a 2 km buffer as calculated from the underlying data used in Figure 8.2 is 0.18 birds/km^2. If it is assumed that 100% of birds within the area in which construction activities will occur (113.1 km^2), then using a bird density of 0.18 birds/km^2 it is predicted that 20 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.

8.5.1.17 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 six years between phases. Therefore the maximum duration over which export cables could be installed is nine years (Table 5.3). 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.

8.5.1.18 Following JNCC *et al.* (2017) interim guidance, a range of mortality rates have been applied to the displaced population of birds (Table 8.7). 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 8.7: 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)	0.20	0.40	1.00	1.99
% of pSPA population	0.01	0.03	0.07	0.13
% increase in baseline mortality	0.08	0.16	0.41	0.82

8.5.1.19 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.

8.5.1.20 Applying a 1% mortality rate results in a predicted mortality of less than one individual bird (Table 8.7). 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.

Conclusions

8.5.1.21 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.

<u>Operation/maintenance</u>

Displacement

8.5.1.22 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).

8.5.1.23 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. 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.

Conclusions

8.5.1.24 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.

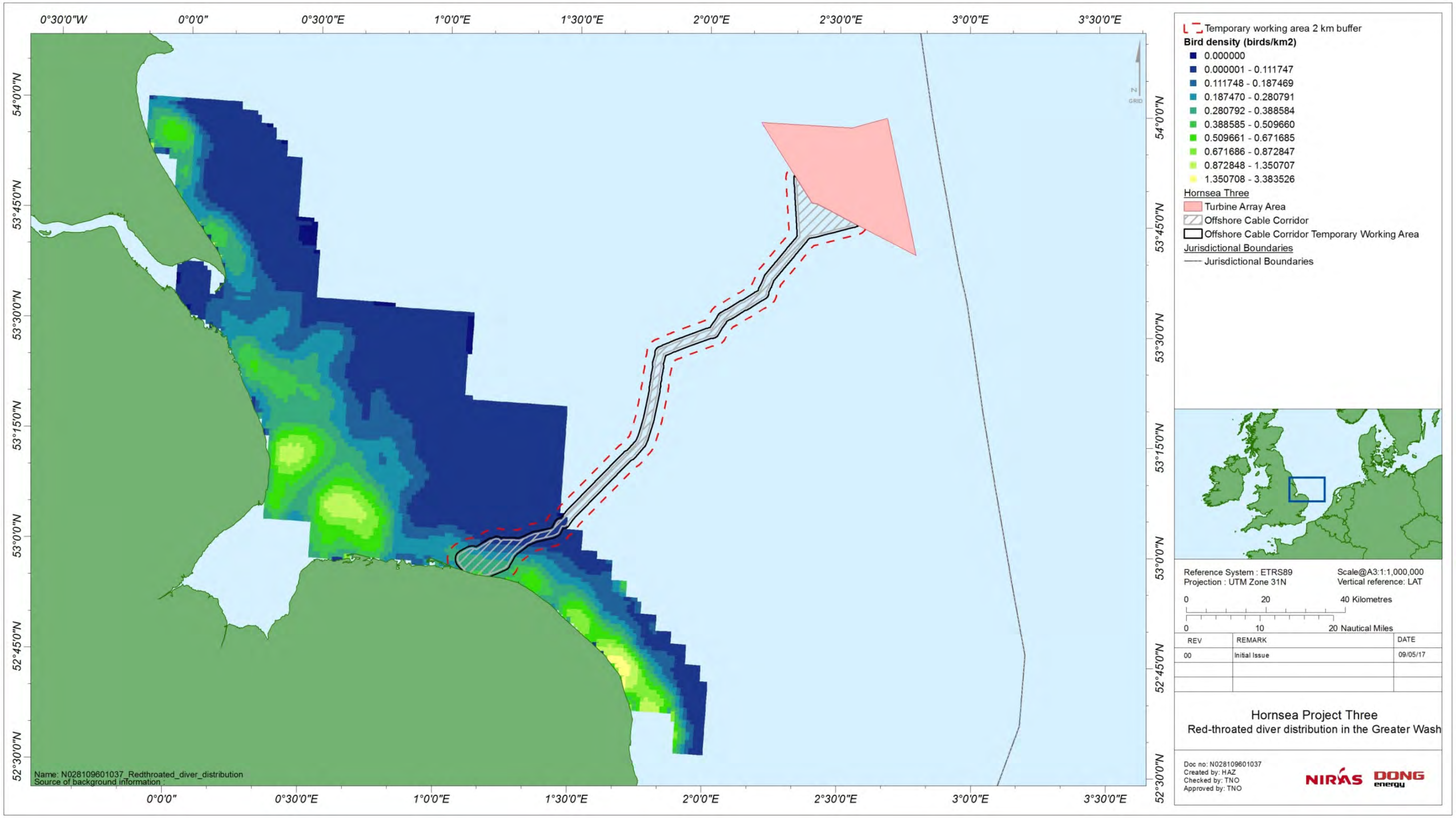

Figure 8.2: Red-throated diver distribution in the Greater Wash (2002-2008); Lawson *et al.*, 2015).

Common scoter

Construction/decommissioning

Disturbance

8.5.1.25 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 of the Project. The absence of common scoter in offshore areas is also supported by the results presented in Stone *et al.* (1995) with high densities of common scoter in inshore areas.

8.5.1.26 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.

8.5.1.27 In order to calculate the magnitude of impact associated with construction activities associated with 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 8.3). 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. Densities of up to 0.02 birds/km^2 were present along the export cable route. These densities have been calculated from the data on which Figure 8.3 is based.

8.5.1.28 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 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 the highest density recorded only 0.002 birds/km^2 as derived from interrogating the underlying data supporting the density map presented in Figure 8.3.

8.5.1.29 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 8.4). 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 will many vessels moving through the Greater Wash Area of Search travelling towards ports in Scotland.

8.5.1.30 The average density of common scoter within the export cable route plus a 2 km buffer is significantly less than 0.01 birds/km^2. Even if it is assumed that displacement will occur throughout the entire export cable route plus a 2 km buffer area (1,168 km2) at the same time, this would affect a population of less than one bird. It should also be noted that these effects will occur within an area that is already disturbed by existing vessel movements.

8.5.1.31 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 six years between phases. Therefore the maximum duration over which export cables could be installed is nine years (Table 5.3). 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.

Conclusions

8.5.1.32 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 / displacement due to construction and decommissioning activities.

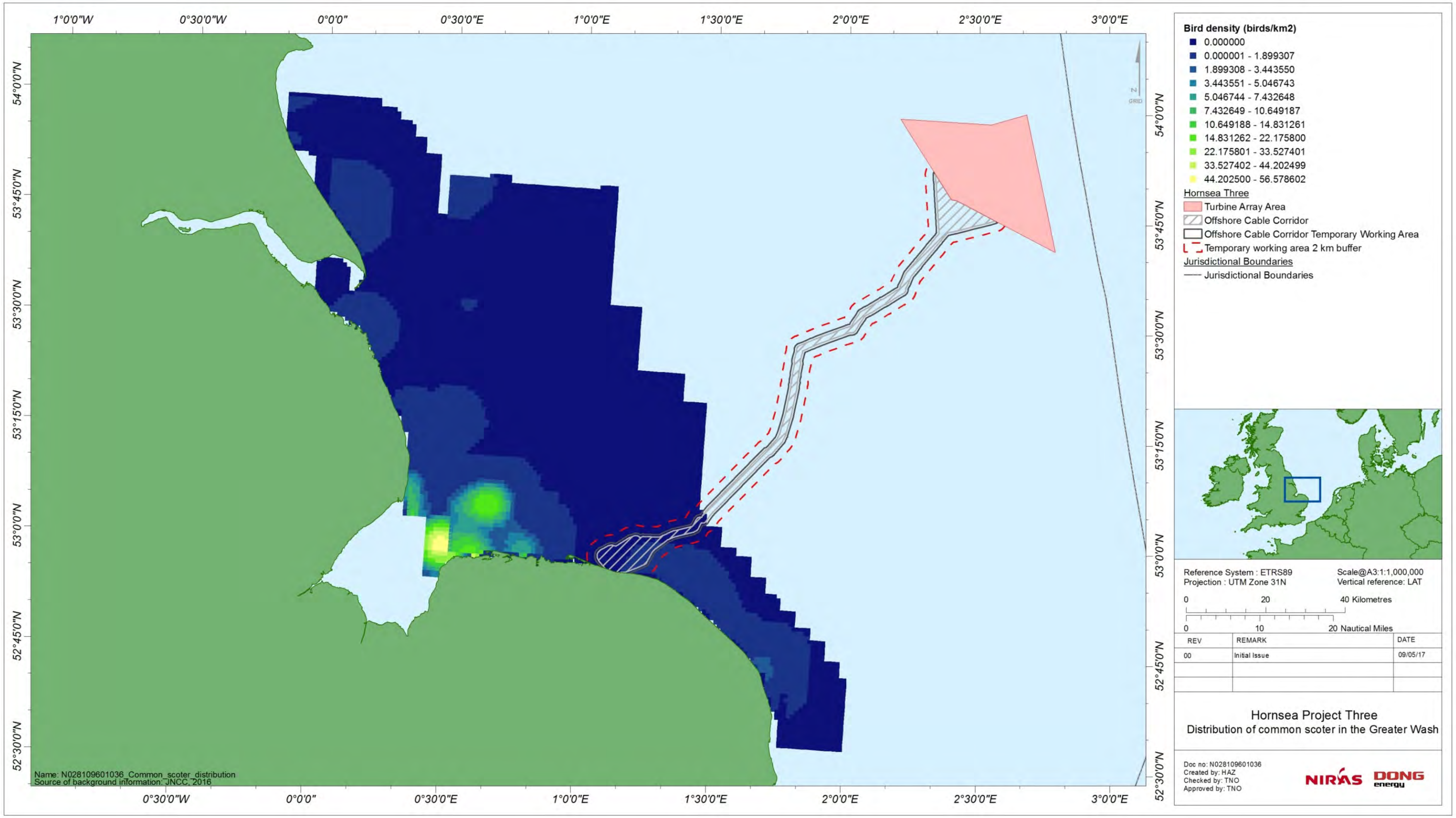

Figure 8.3: Distribution of common scoter in the Greater Wash (2002 – 2008; Lawson *et al.*, 2015).

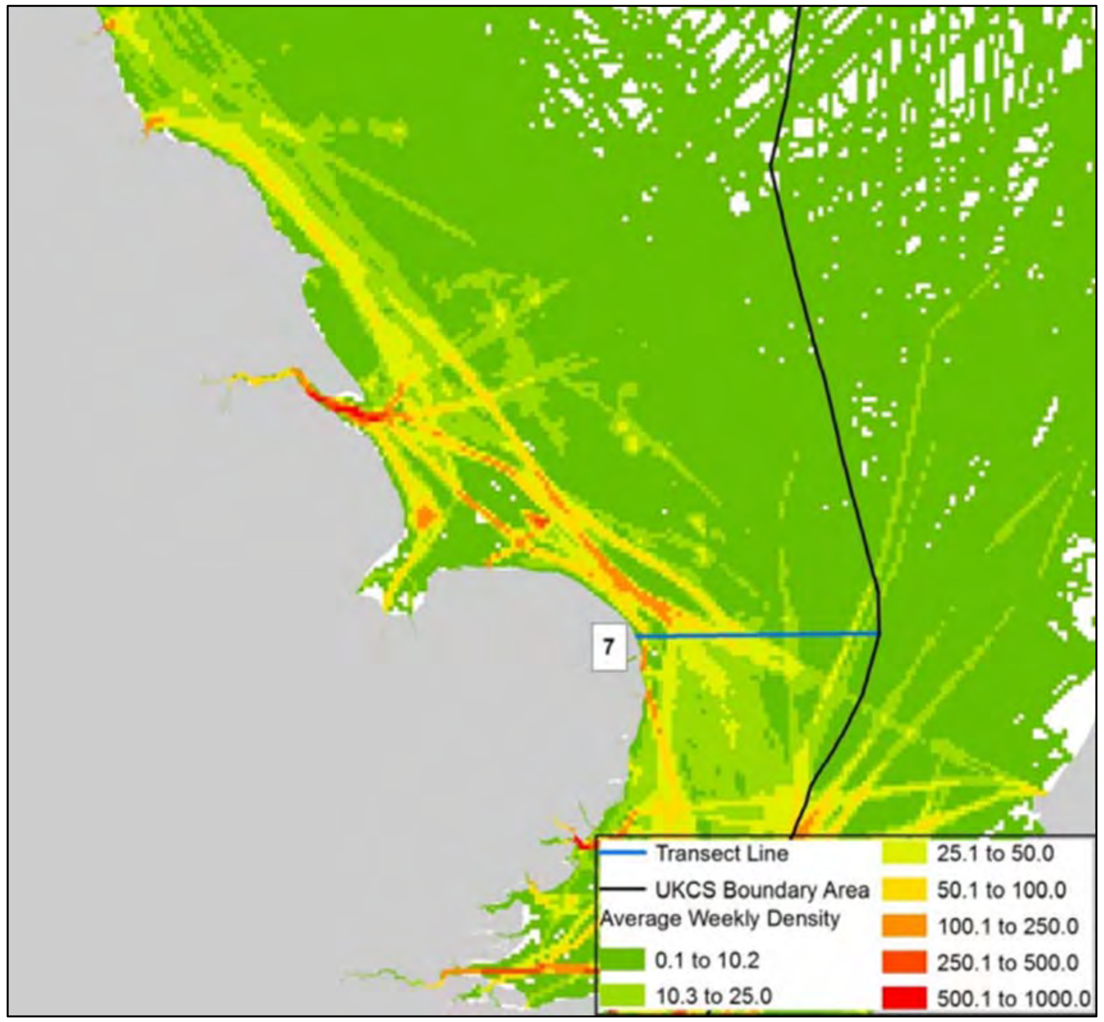

Figure 8.4: East coast vessel density and routes 2012 (Source: MMO, 2014).

Operation/maintenance

Displacement

8.5.1.33 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. Common scoter is considered to have a high sensitivity to disturbance from vessels (Wade *et al.,* 2016).

8.5.1.34 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 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.

Conclusions

8.5.1.35 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.

8.5.2 Flamborough and Filey Coast pSPA/ Flamborough Head and Bempton Cliffs SPA from the Project

Site description

8.5.2.1 The Flamborough and Filey Coast 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 100 km from Project Two, 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 (83,370 pairs). The proposed SPA citation 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 and 490 pairs of puffin.

Features screened into assessment

8.5.2.2 The screening assessment identified the potential for LSE on the following features of this pSPA:

- Gannet (collision and displacement in the breeding, pre-breeding and post-breeding season);
- Puffin (displacement in the breeding and non-breeding seasons);
- Guillemot (displacement in the non-breeding season;
- Razorbill (displacement in the non-breeding seasons); and
- Kittiwake (collision in the breeding, pre-breeding and post-breeding seasons).

8.5.2.3 A summary of the screening process is presented in Table 8.8.

Table 8.8: Results of the screening process with respect to the Filey and Flamborough pSPA.

Feature	Project Phase	Potential Impact	Likely Significant Effect
Fulmar	Construction/decommissioning	Disturbance	No
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	No
		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[8]
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Potential for LSE[6]
		Changes to prey availability	No
Razorbill	Construction/decommissioning	Disturbance	Potential for LSE[6]
		Changes to prey availability	No
	Operation	Collision risk	No
		Displacement	Potential for LSE[6]
		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[6]
		Displacement	No
		Changes to prey availability	No

Gannet

8.5.2.4 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 2014).

8.5.2.5 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, Teuten and Butler, 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.

8.5.2.6 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.

8.5.2.7 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 8.5) (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.

[8] Non-breeding season only

8.5.2.8 It is evident from Figure 8.5 and the annual reports (Langston, Teuten and Butler, 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, Teuten and Butler (2013), and so it is unlikely that it forms a notably important foraging area for this species.

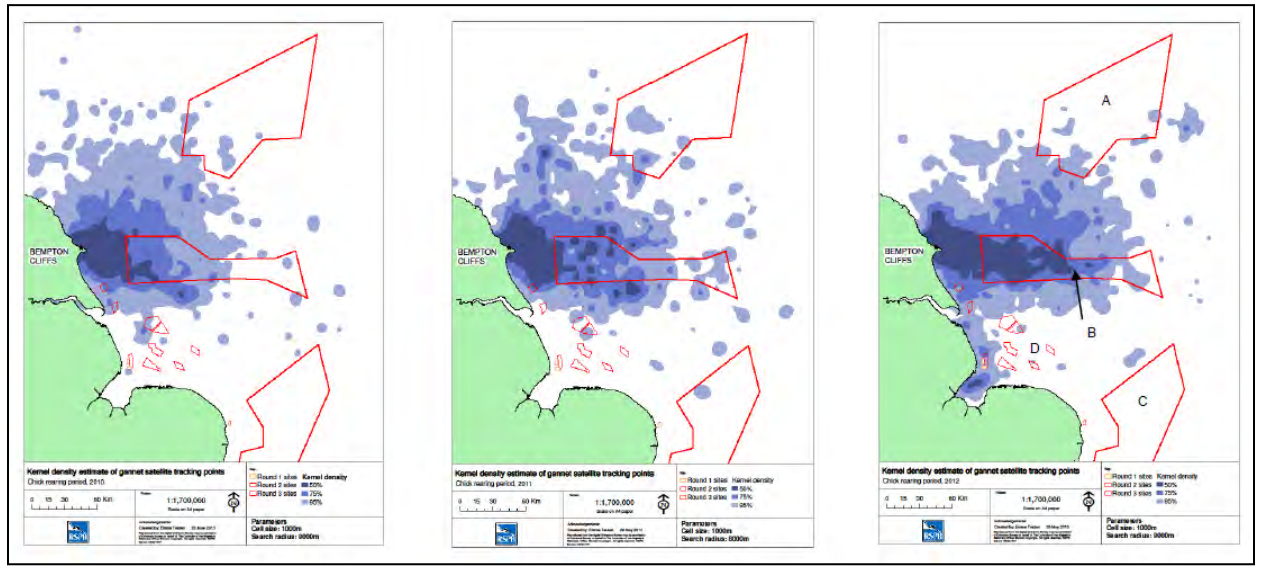

Figure 8.5: Gannet foraging Kernel Density Estimation (kernel density tool, ArcGIS Desktop 10) from satellite-tagged birds from Bempton Cliffs breeding colony in 2010 (left), 2011 (middle) and 2012 (right) during the chick-rearing period, showing the 50%, 75% and 95% density contours. From Langston, Teuten and Butler (2013)[a].

a Quality of figure is due to the image being a copy from Langaton, Teuten and Butler (2013).

8.5.2.9 Aerial survey data collected between April 2016 and February 2017 has only recorded the age class of a limited number of birds in the breeding season (50 birds). This is considered to be too few birds to allow for consideration of the age structure of birds at Hornsea Three. As such, 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 14,150 gannets. Of these gannets, 71.9% were adults with the remaining 28.1% immature birds.

8.5.2.10 The post-breeding (autumn) BDMPS population from Furness (2015) is 456,299 individuals of which 4.8% are from the colony at Flamborough and Filey Coast pSPA.

8.5.2.11 In the pre-breeding season (spring), the BDMPS population is an estimated 248,385 gannets (Furness, 2015). Gannets from Flamborough and Filey Coast pSPA represent 6.2% of this population.

Operation/maintenance

Collision risk

8.5.2.12 Using the values detailed above, collision risk estimates calculated using the Band (2012) CRM have been apportioned to the Flamborough and Filey Coast pSPA gannet population in Table 8.9.

Table 8.9: Gannet collision risk estimates apportioned to Flamborough and Filey Coast pSPA.

Season	Predicted no. of collisions (no apportioning)		Apportioning value (%)	No. of collisions apportioned to pSPA	
	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)		Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)
Breeding	14	6	71.9	10	4
Post-breeding	6	3	4.8	0	0
Pre-breeding	13	6	6.2	1	0
Total	33	14		11	5

8.5.2.13 Collision risk modelling, using Option 3, predicts a total collision risk mortality of 14 gannet at Hornsea Three across a full annual cycle (98% avoidance) with 5 of these apportioned to the pSPA. This represents 0.03% of the pSPA population (8,469 pairs) and 0.4% increase in baseline mortality.

Conclusion

8.5.2.14 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 indication, at this stage (pending a complete baseline data set), of an adverse effect on the integrity of the gannet population of the Flamborough and Filey Coast pSPA as a result of collision mortality due to operation and maintenance activities.

Displacement

8.5.2.15 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 lower 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 value of 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.

8.5.2.16 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 are dependent on species behaviour. 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.

Breeding season

8.5.2.17 The peak gannet population estimate within Hornsea Three and 2 km buffer during the breeding season (Apr-Aug) that can be apportioned to the pSPA is 667 birds. Displacement analysis for gannet predicts mortality of 9 gannet in the breeding season based on a displacement rate of 70% and a mortality rate of 2% (Table 8.10). Therefore birds lost to the population as a result of displacement represent 0.05% of the pSPA breeding population (8,469 pairs) and would result in a 0.66% increase in background mortality, which is 0.081 (Horswill & Robinson 2015).

Post-breeding season

8.5.2.18 The peak gannet population estimate within Hornsea Three and 2 km buffer during the post-breeding season that can be apportioned to the pSPA is 13 birds. Displacement analysis for gannet predicts mortality of zero gannet in the post-breeding season based on a displacement rate of 70% and a mortality rate of 1% (Table 8.11). Therefore no birds would be lost to the population as a result of displacement in this season.

Table 8.10: Predicted gannet mortality from Flamborough and Filey Coast pSPA as a result of displacement from Hornsea Three and 2 km buffer during the breeding season.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	1	3	7	13	20	27	33	40	47	53	60	67
20	1	3	7	13	27	40	53	67	80	93	107	120	133
30	2	4	10	20	40	60	80	100	120	140	160	180	200
40	3	5	13	27	53	80	107	133	160	187	213	240	267
50	3	7	17	33	67	100	133	167	200	233	267	300	333
60	4	8	20	40	80	120	160	200	240	280	320	360	400
70	5	9	23	47	93	140	187	233	280	327	373	420	467
80	5	11	27	53	107	160	213	267	320	373	427	480	534
90	6	12	30	60	120	180	240	300	360	420	480	540	600
100	7	13	33	67	133	200	267	333	400	467	534	600	667

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Table 8.11: Predicted gannet mortality from Flamborough and Filey Coast 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	0	0	1	1	1	1	1	1	1
20	0	0	0	0	1	1	1	1	2	2	2	2	3
30	0	0	0	0	1	1	2	2	2	3	3	4	4
40	0	0	0	1	1	2	2	3	3	4	4	5	5
50	0	0	0	1	1	2	3	3	4	5	5	6	7
60	0	0	0	1	2	2	3	4	5	6	6	7	8
70	0	0	0	1	2	3	4	5	6	7	8	8	9
80	0	0	1	1	2	3	4	5	6	8	9	10	11
90	0	0	1	1	2	4	5	6	7	8	10	11	12
100	0	0	1	1	3	4	5	7	8	9	11	12	13

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Table 8.12: Predicted gannet mortality from Flamborough and Filey Coast 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	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	16	19	21	23
50	0	1	1	3	6	9	12	15	18	20	23	26	29
60	0	1	2	4	7	11	14	18	21	25	28	32	35
70	0	1	2	4	8	12	16	20	25	29	33	37	41
80	0	1	2	5	9	14	19	23	28	33	37	42	47
90	1	1	3	5	11	16	21	26	32	37	42	47	53
100	1	1	3	6	12	18	23	29	35	41	47	53	58

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Pre-breeding season

8.5.2.19 The peak gannet population estimate within Hornsea Three and 2 km buffer during the pre-breeding season that can be apportioned to the pSPA is 58 birds. Displacement analysis for gannet predicts mortality of zero gannet in the pre-breeding season based on a displacement rate of 70% and a mortality rate of 1% (Table 8.12). Therefore no birds would be lost to the population as a result of displacement in this season.

Conclusion

8.5.2.20 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 indication, at this stage (pending a complete baseline data set), of an adverse effect on the integrity of the gannet population of the Flamborough and Filey Coast pSPA as a result of displacement due to operation and maintenance activities.

Kittiwake

Operation/maintenance

Collision risk

8.5.2.21 Kittiwake was rated as being 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, including at night. 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.

8.5.2.22 The Flamborough & Filey Coast 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 as reported by Thaxter *et al.* (2012). Preliminary results from the FAME project which has tracked breeding kittiwake from the Filey and Flamborough pSPA colony does however suggest that there may be connectivity between the pSPA and Hornsea Three.

8.5.2.23 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. Based on the proportion of first year birds observed, and the likely age structure of the kittiwake population (Smart Wind, 2015b)it is considered that adults will comprise no more than 83% of the individuals observed at Hornsea Three. Whilst this proportion has been used to apportion collision to the breeding population of the pSPA, it is considered highly precautionary. It does not, for example, account for the likely presence of a substantial number of non-breeding adult birds nor the low likelihood that breeding adult birds associated with the pSPA colony will regularly forage so far offshore. Further work will be undertaken to address these factors ahead of the final application submission and this will be discussed with the Ornithology EWG. Initial collision values presented in this document (for example Table 8.13) do not currently take this into account and it is therefore expected that these values will reduce further once additional consideration has been given to the proportion of non-breeders in the population.

8.5.2.24 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 7.1% respectively based on the assumed contribution of the Flamborough and Filey Coast pSPA to the relevant BDMPS populations (Furness 2015).

8.5.2.25 A preliminary assessment of collision risk has been undertaken for kittiwake using Band (2012). The preliminary results for Options 2 and 3 of this model are presented in Table 8.13. For the purposes of this preliminary assessment, it is considered that model predictions provide an approximate indication of the likely risk.

Table 8.13: Kittiwake collision risk estimate apportioned to Flamborough and Filey Coast pSPA

Season	Predicted no. of collisions (no apportioning)			Apportioning value (%)	No. of collisions apportioned to pSPA		
	Option 2 (98.9% avoidance rate)	Option 2 (99.2% avoidance rate)	Option 3 (98% avoidance rate)		Option 2 (98.9% avoidance rate)	Option 2 (99.2% avoidance rate)	Option 3 (98% avoidance rate)
Breeding [a]	222	162	81	83.0	185	134	67
Post-breeding	102	74	37	5.4	5	4	2
Pre-breeding	17	12	6	7.1	1	1	0
Total	341	248	124		191	139	69

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 Flamborough and Filey Coast pSPA. The breeding population against which this rate is compared in the breeding season, however, comprises only breeding adult birds.

8.5.2.26 The total predicted collision mortality rate for kittiwake at Hornsea Three is 124 (Option 3) across a full annual cycle (98% avoidance) with 69 of these apportioned to the pSPA. This represents 0.08% of the pSPA population and 0.53 % increase in baseline mortality.

Conclusion

8.5.2.27 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 indication, at this stage (pending a complete baseline data set), of an adverse effect on the integrity of the kittiwake population of the Flamborough and Filey Coast 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

<u>Construction/decommissioning/operation</u>

Disturbance/displacement

8.5.2.28 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.

8.5.2.29 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 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.

8.5.2.30 The mean-maximum foraging range 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.

8.5.2.31 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 likely to be present at Hornsea Three is very small (< 1 individual). During the non-breeding season the proportion of breeding adult birds is 0.41%. based on the assumed contribution of the Flamborough and Filey Coast pSPA to the relevant BDMPS populations (Furness 2015). Further work will be undertaken to address these factors ahead of the final application submission and this will be discussed with the Ornithology EWG. Initial displacement values presented in this document (for example Table 8.14).

8.5.2.32) do not currently take this into account and it is therefore expected that these values will reduce further once additional consideration has been given to the proportion of non-breeders in the population.

8.5.2.33 With regards to displacement and mortality rates that form the focus of the assessment due to the moderate sensitivity of the species, 40% displacement and 10% mortality is considered appropriately precautionary for the breeding season. For the non-breeding season, 40% displacement and 1% mortality is highlighted.

Breeding season

8.5.2.34 Considering the prediction that less than 1 breeding adult associated with the breeding colony at the Flamborough and Filey Coast pSPA is expected to be present at Hornsea Three in the breeding season there is considered to be no risk from displacement effects during this season.

Non-breeding season

8.5.2.35 The peak puffin population estimate within Hornsea Three and 2 km buffer during the non-breeding season that can be apportioned to the pSPA is 5 birds. Displacement analysis for gannet puffin predicts mortality of zero puffin in the non-breeding season based on a displacement rate of 40% and a mortality rate of 1% (Table 8.14). Therefore no birds would be lost to the population as a result of displacement in this season.

Conclusion

8.5.2.36 There are no predicted mortality of puffin associated with the breeding colony of the Flamborough and Filey Coast pSPA as a result of displacement from Hornsea Three in any biological season. There is, therefore, no indication of an adverse effect on the puffin breeding feature at Flamborough and Filey Coast pSPA as a result of disturbance or displacement due to operation and maintenance activities.

Table 8.14: Predicted puffin mortality from Flamborough and Filey Coast 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	1	1	1	1	1
30	0	0	0	0	0	0	1	1	1	1	1	1	1
40	0	0	0	0	0	1	1	1	1	1	2	2	2
50	0	0	0	0	0	1	1	1	1	2	2	2	2
60	0	0	0	0	1	1	1	1	2	2	2	3	3
70	0	0	0	0	1	1	1	2	2	2	3	3	3
80	0	0	0	0	1	1	2	2	2	3	3	3	4
90	0	0	0	0	1	1	2	2	3	3	3	4	4
100	0	0	0	0	1	1	2	2	3	3	4	4	5

Key: < 1% background mortality; > 1% background mortality/>1% SPA population; > 1% SPA population

Razorbill

Construction/decommissioning/operation

Disturbance/displacement

8.5.2.37 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.

8.5.2.38 During the breeding season, the mean foraging range of breeding razorbills from the Flamborough and Filey Coast pSPA colony 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).

8.5.2.39 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.

8.5.2.40 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.

8.5.2.41 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).

8.5.2.42 During the non-breeding season the proportion of breeding adult is 2.74% and during post- and pre-breeding seasons the proportion is 3.38% based on the assumed contribution of the Flamborough and Filey Coast pSPA to the relevant BDMPS populations (Furness 2015). Further work will be undertaken to address these factors ahead of the final application submission and this will be discussed with the Ornithology EWG. Initial displacement values presented in this document (for example Table 8.15) do not currently take this into account and it is therefore expected that these values will reduce further once additional consideration has been given to the proportion of non-breeders in the population.

8.5.2.43 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% (post- and pre-breeding seasons) and 1% (non-breeding season) are highlighted for assessment focus.

Post-breeding season

8.5.2.44 The peak razorbill population estimate within Hornsea Three and 2 km buffer during the post-breeding season that can be apportioned to the pSPA is 13 birds. Displacement analysis for predicts mortality of zero razorbill the post-breeding season based on a displacement rate of 40% and a mortality rate of 2% (Table 8.15).

Non-breeding season

8.5.2.45 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 104 birds. Displacement analysis for predicts mortality of zero razorbill the non-breeding season based on a displacement rate of 40% and a mortality rate of 1% (Table 8.16).

Table 8.15: Predicted razorbill mortality from Flamborough and Filey Coast 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	0	0	1	1	1	1	1	1	1
20	0	0	0	0	1	1	1	1	2	2	2	2	3
30	0	0	0	0	1	1	2	2	2	3	3	4	4
40	0	0	0	1	1	2	2	3	3	4	4	5	5
50	0	0	0	1	1	2	3	3	4	5	5	6	7
60	0	0	0	1	2	2	3	4	5	6	6	7	8
70	0	0	0	1	2	3	4	5	6	7	8	8	9
80	0	0	1	1	2	3	4	5	6	8	9	10	11
90	0	0	1	1	2	4	5	6	7	8	10	11	12
100	0	0	1	1	3	4	5	7	8	9	11	12	13

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Table 8.16: Predicted razorbill mortality from Flamborough and Filey Coast 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	15	17	19	21
30	0	1	2	3	6	9	12	16	19	22	25	28	31
40	0	1	2	4	8	12	17	21	25	29	33	37	42
50	1	1	3	5	10	16	21	26	31	36	42	47	52
60	1	1	3	6	12	19	25	31	37	44	50	56	62
70	1	1	4	7	15	22	29	36	44	51	58	65	73
80	1	2	4	8	17	25	33	42	50	58	66	75	83
90	1	2	5	9	19	28	37	47	56	65	75	84	93
100	1	2	5	10	21	31	42	52	62	73	83	93	104

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Table 8.17: Predicted razorbill mortality from Flamborough and Filey Coast 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	1	1	1	1	1	2	2	2
20	0	0	0	0	1	1	2	2	2	3	3	3	4
30	0	0	0	1	1	2	2	3	3	4	5	5	6
40	0	0	0	1	2	2	3	4	5	5	6	7	8
50	0	0	0	1	2	3	4	5	6	7	8	9	10
60	0	0	1	1	2	3	5	6	7	8	9	10	12
70	0	0	1	1	3	4	5	7	8	10	11	12	14
80	0	0	1	2	3	5	6	8	9	11	12	14	16
90	0	0	1	2	3	5	7	9	10	12	14	16	17
100	0	0	1	2	4	6	8	10	12	14	16	17	19

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Pre-breeding season

8.5.2.46 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 19 birds. Displacement analysis for razorbill predicts mortality of zero razorbill the post-breeding season based on a displacement rate of 40% and a mortality rate of 2% (Table 8.17).

Conclusion

8.5.2.47 There is no predicted displacement mortality of adult razorbill originating from the pSPA due to Hornsea Three in any biological season. There is, therefore, no indication of an adverse effect on the razorbill breeding feature at Flamborough and Filey Coast pSPA as a result of disturbance or displacement due to operation and maintenance activities.

Guillemot

Construction/decommissioning/operation

Disturbance/displacement

8.5.2.48 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.

8.5.2.49 During the breeding season, the mean foraging range of breeding guillemots from the Flamborough and Filey Coast pSPA colony 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 2 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.

8.5.2.50 On the basis that the foraging range falls short of the Hornsea Three array area, breeding season displacement effects resulting from Hornsea Three have been screened out of the assessment.

8.5.2.51 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.

8.5.2.52 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.

8.5.2.53 During the non-breeding season the proportion of breeding adult is 4.4% based on the assumed contribution of the Flamborough and Filey Coast pSPA to the relevant BDMPS populations (Furness 2015). Further work will be undertaken to address these factors ahead of the final application submission and this will be discussed with the Ornithology EWG. Initial displacement values presented in this document (for example Table 8.17) do not currently take this into account and it is therefore expected that these values will reduce further once additional consideration has been given to the proportion of non-breeders in the population.

8.5.2.54 With regards to displacement and mortality rates that form the focus of the assessment, 40% displacement and 10% mortality is considered appropriately precautionary for the breeding season. For the non-breeding season, 40% displacement and 1% mortality is highlighted.

Non-breeding season

8.5.2.55 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 608 birds. Displacement analysis for predicts mortality of two guillemot in the non-breeding season based on a displacement rate of 30% and a mortality rate of 1% (Table 8.18).

8.5.2.56 Therefore guillemot lost to the pSPA population as a result of displacement represent 0.004% of the pSPA breeding population (41,607 pairs) and would result in a negligible increase in background mortality.

Conclusion

8.5.2.57 There are 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. There is, therefore, no indication of an adverse effect on the guillemot breeding feature at Flamborough and Filey Coast pSPA as a result of disturbance or displacement due to operation and maintenance activities.

Table 8.18: Predicted guillemot mortality from Flamborough and Filey Coast 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	1	3	6	12	18	24	30	36	43	49	55	61
20	1	2	6	12	24	36	49	61	73	85	97	109	122
30	2	4	9	18	36	55	73	91	109	128	146	164	182
40	2	5	12	24	49	73	97	122	146	170	194	219	243
50	3	6	15	30	61	91	122	152	182	213	243	273	304
60	4	7	18	36	73	109	146	182	219	255	292	328	365
70	4	9	21	43	85	128	170	213	255	298	340	383	425
80	5	10	24	49	97	146	194	243	292	340	389	438	486
90	5	11	27	55	109	164	219	273	328	383	438	492	547
100	6	12	30	61	122	182	243	304	365	425	486	547	608

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

8.6 In-combination assessment methodology

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

8.6.1.1 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 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.

8.6.1.2 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 a cumulative 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 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 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;
- 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.

8.6.1.3 The specific projects scoped into this in-combination assessment and the Tiers into which these have been allocated, are outlined in Table 8.19. 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.

Table 8.19: 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*						
	Construction	Aberdeen Demo	444	Up to 100MW with no more than 11 turbines	2019	No	Yes
		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
		Dogger Bank Creyke Beck A	76	Up to 1.2GW (Up to 200 turbines of up to 10MW capacity)	2021 – 2024	Yes	Yes
		Dogger Bank Creyke Beck B	99	Up to 1.2GW (Up to 200 turbines of up to 10MW turbines)	2021 – 2024	Yes	Yes
		Dogger Bank Teesside A	107	Up to 1.2GW	2023 - 2026	Yes	Yes
		Dogger Bank Teesside B	95	Up to 1.2GW	2023 - 2026	Yes	Yes
		Dudgeon	87	20 miles off the coast of Cromer, N North Norfolk. Up to 402 MW and 67 turbines	2015 – 2017	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 300 6-15MW turbines (DCO)	2017 – 2018	No	Yes
		Hywind Scotland Pilot Park	438	30MW (5x6MW turbines)	2019	No	Yes
		Inch Cape	384	Up to 784MW (95-110 turbines of up to 7 - 8MW capacity) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		Moray East	548	1116MW Up to 137 turbines	Not known	Not known	Yes
		Neart na Gaoithe	372	448MW (64x7MW turbines) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		Race Bank	114	Up to 580MW	2017 - 2018	No	Yes
		Rampion Wind Farm	388	400MW (116x3.45MW)	2017 - 2018	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
		SeaGreen Alpha	383	Up to 525MW (75x7MW) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		Seagreen Bravo	367	Up to 525MW (75x7MW) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		Triton Knoll	100	Up to 288 turbines consented	2017 – 2021	No	Yes
	Operation and maintenance	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
		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
		Shreingham 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

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
		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*						
	Application	Norfolk Vanguard	73	Up to 1800MW (between 120 - 257 turbines of up to 7 - 15MW capacity)	2020 – 2022	Yes	Yes
		East Anglia Three	103	Up to 1200MW (up to 172 turbines of up to 7 - 12MW capacity)	2020 – 2022	Yes	Yes
		Kincardine Offshore Wind Farm	422	48MW (8x6MW turbines)	2019	No	Yes
		Moray West	554	750MW Up to 90 turbines	2022-2024	Yes	Yes
		Methil Demonstration Project - 2B Energy	411	Demonstrator site	Not known	Not known	Yes
	Judicial Review	Inch Cape	384	Up to 784MW (95-110 turbines of up to 7 - 8MW capacity) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		Neart na Gaoithe	372	448MW (64x7MW turbines) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		SeaGreen Alpha	383	Up to 525MW (75x7MW) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
		Seagreen Bravo	367	Up to 525MW (75x7MW) Consent over-turned on Judicial Review (currently being appealed)	After 2019	Yes	Yes
	Cables						
	Application	Viking Link Interconnector	13	High voltage (up to 500 kV) Direct Current (DC) electricity interconnector	2018	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
3	Offshore wind farms						
	Pre-planning	Hornsea Project Four	36	1,000 MW	After 2020	Yes	Yes
		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

8.6.2 Maximum design scenario

8.6.2.1 The maximum design scenarios identified in Table 8.20 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative 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 cumulative 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 8.20: 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 For Hornsea Three it is assumed (see Table 5.3) Up to 11,566 vessel movements during construction, comprised of: • Up to 4,446 vessel movements over construction period based on gravity base foundations (self-installing concept); • Up to 3,420 vessel movements over construction period for Wind Turbine Generator (WTG) installation; • Up to 304 vessel movements over construction period for substations; • Up to 2,856 vessel movements over construction period for array cables; and; • Up to 540 vessel movements over construction period for export cable. The offshore components of Hornsea Three will occur over a maximum duration of 11 years, assuming a two phase construction scenario. A gap of six years may occur between the same activity in different phases. 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 (see Table 5.3). Comprising of up to 342 x Wind Turbine Generators (WTG), 12 offshore HVAC collector substations, three offshore accommodation platforms, and four offshore HVDC substations and associated construction activity including: • Maximum construction activity level (magnitude) as indicated in *Table 5.3* • Maximum construction activity duration as indicated in *Table 5.3* This will be assessed cumulatively with projects with Tier 1 and 2 projects with overlapping construction programmes: Tier 1 • Dogger Bank Creyke Beck A • Dogger Bank Creyke Beck B • Dogger Bank Teesside A • Dogger Bank Teesside B Tier 2 • Norfolk Vanguard • East Anglia Three	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 a 11 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.	For Hornsea Three it is assumed that the operation of maximum number of turbines (up to 342 WTGs), within the total wind farm area of 696 km^2, with a minimum of 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore HVAC collector substations, up to three offshore accommodation platforms and four offshore HVAC booster stations (part way along cable route)) and up to three offshore accommodation platforms. Infrastructure placed up to the edge of Hornsea Three. This will be assessed cumulatively with all projects included in each Tier.	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.

Potential impact	Maximum design scenario	Justification
Mortality from collision with rotating turbine blades	For Hornsea Three it is assumed that there will be operation of maximum number of turbines (up to 342 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 area of 696 km^2, with a minimum of 1,000 m spacing. This will be assessed cumulatively with all projects included in each Tier.	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.	For Hornsea Three is assumed that there will be up to 2,832 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 (87 return trips per year over the design life of the project (i.e. 25 years). • Up to 25,234 helicopter flights per year comprising of: • 22,572 wind turbine visits;1,102 platform visits; and • 1,560 crew shift transfers. This will be assessed cumulatively with all projects included in each Tier.	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.

8.7 Assessment of potential effect on site integrity in-combination with other plans and projects

8.7.1 Greater Wash pSPA

Red-throated diver

Construction/decommissioning

Disturbance

8.7.1.1 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.

8.7.1.2 Those Tier 1 projects predicted to overlap with the construction of Hornsea Three are the Dogger Zone projects (Creyke Beck A & B and Teesside A & 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 offshore components of Hornsea Three will occur over a maximum duration of 11 years, assuming a two phase construction scenario (Table 5.3). A gap of six years may occur between the same activity 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).

8.7.1.3 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 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 red-throated diver.

8.7.1.4 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).

8.7.1.5 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.

Conclusions

8.7.1.6 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.

In Operation/maintenance

Displacement

8.7.1.7 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.

8.7.1.8 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).

8.7.1.9 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.

8.7.1.10 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.

8.7.1.11 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.

Conclusions

8.7.1.12 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

8.7.1.13 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.

8.7.1.14 Those Tier 1 projects predicted to overlap with the construction of Hornsea Three are the Dogger Zone projects (Creyke Beck A & B and Teesside A & 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 offshore components of Hornsea Three will occur over a maximum duration of 11 years, assuming a two phase construction scenario (Table 5.3). A gap of six years may occur between the same activity 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).

8.7.1.15 At this stage, the likely origin and routing of vessels involved in the construction of Hornsea Three or any of the Dogger 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 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.

8.7.1.16 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).

8.7.1.17 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.

Conclusions

8.7.1.18 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

8.7.1.19 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.

8.7.1.20 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.

8.7.1.21 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.

8.7.1.22 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.

8.7.1.23 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.

Conclusions

8.7.1.24 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.

8.7.2 Flamborough and Filey Coast pSPA/ Flamborough Head and Bempton Cliffs SPA from the Project

Gannet

Operation/maintenance

Collision risk

8.7.2.1 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.

8.7.2.2 For the three Hornsea projects the apportioning value for the breeding season calculated is applied following the approach applied 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. 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.

8.7.2.3 Table 8.21 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.

8.7.2.4 For Tier 1 projects, a total in-combination collision risk mortality of 203 gannet is predicted across a full annual cycle that are apportioned to the pSPA. This represents 1.2% of the pSPA population and a 14.8% increase in baseline mortality. When Tier 2 projects are included, the in-combination collision risk mortality is 205, which represents 1.2% of the pSPA population and a 14.9% increase in baseline mortality.

Conclusion

8.7.2.5 Further discussion of the appropriate parameters to be used in the analysis and modelling of likely mortality of the effects of wind farms on the breeding population of gannet will be undertaken through the Evidence Plan process. The appropriate way to assess the implications of predicted mortality on reference populations will also be explored and agreed through the Evidence Plan process. The expectation however is that Population Viability Analysis (PVA) modelling outputs will be used to assess the significance of the predicted mortality impacts from collision on gannet which breed at the colony which comprise the Flamborough and Filey Coast (FFC) pSPA. The population models will be those already undertaken for Hornsea Project Two (SMart Wind 2015).

Table 8.21: Predicted in-combination collision mortality for gannet[9]

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	14	6	72	4	3	4.8	0	6	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	42				21	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
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	Band (2012)	3	98	136	68	50	34	34	4.8	2	34	6.2	2
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				64	4.8	3	2	6.2	0
Galloper	Band *et al.* (2007)	1	98.9	62				31	4.8	1	13	6.2	1
Greater Gabbard	Band (2000)	1	98.9	28				9	4.8	0	5	6.2	0
Hornsea Project One	Band (2012)	4	98	38	7	72	5	18	4.8	1	13	6.2	1
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
Inch Cape	Band (2012)	1	98.9	371				29	4.8	1	5	6.2	0
Kentish Flats Extension	Band (2012)	1	98.9	3				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

[9] 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
London Array	Band (2000)	1	98.9	6				1	4.8	0	2	6.2	0
Moray Firth Project One (MORL)	Band (2012)	3	98	18				5	4.8	0	1	6.2	0
Neart na Gaoithe	Band (2012)	1	98.9	570				30	4.8	1	30	6.2	2
Race Bank	Band (2000)	1	98.9	50	34	100	34	12	4.8	1	4	6.2	0
Seagreen Alpha	Band (2012)	3	98	494				21	4.8	1	28	6.2	2
Seagreen Bravo	Band (2012)	3	98	332				23	4.8	1	31	6.2	2
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	27	100	27	64	4.8	3	30	6.2	2
Westermost Rough	Band *et al.* (2007)	1	98.9	1	0	100	0	0	4.8	0	0	6.2	0
Tier 1 total							165			22			16
Tier 2													
East Anglia Three	Band (2012)	3	98	48				33	4.8	2	10	6.2	1
Overall total							165			24			17

Operations/maintenance

Displacement

8.7.2.6 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 Dogger Bank Teesside A&B. The total displacement mortality associated with these projects is 15 based on the displacement and mortality rates applied in the assessments for each project.

8.7.2.7 There is no additional information available for in-combination effects and so the combined predicted mortality of Hornsea Three (9 individuals) together with Hornsea Project One, Hornsea Project Two, Dogger Bank Creyke Beck A & B and Dogger Bank Teesside A&B is assumed to be 24 gannets.

8.7.2.8 This represents 0.14% of the Flamborough and Filey Coast pSPA population and results in an increase in background mortality of 1.75%.

Conclusion

8.7.2.9 Further discussion of the appropriate parameters to be used in the analysis and modelling of likely mortality of the effects of wind farms on the breeding population of gannets will be undertaken through the Evidence Plan process. The appropriate way to assess the implications of predicted mortality on reference populations will also be explored and agreed through the Evidence Plan process. The expectation however is that Population Viability Analysis (PVA) modelling outputs will be used to assess the significance of the predicted mortality impacts from displacement on gannet which breed at the colony which comprise the Flamborough and Filey Coast (FFC) pSPA. The population models will be those already undertaken for Hornsea Project Two (SMart Wind 2015).

Kittiwake

Operations/maintenance

Collision risk

8.7.2.10 During the breeding season, a foraging range approach has been used to identify those plans and projects that may have connectivity with the Flamborough and Filey Coast pSPA. Based on FAME tracking data a mean-maximum foraging range of 156 km has been used. However, it is important to note that this is the maximum mean-maximum foraging range with considerable variability between years (e.g. using tacking data from 2011 yields a mean-maximum foraging range of 58 km).

8.7.2.11 Table 8.22 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.

8.7.2.12 For Tier 1 projects, a total in-combination collision risk mortality of 174 kittiwake is predicted across a full annual cycle that are apportioned to the pSPA. This represents 0.2% of the pSPA population and a 1.3% increase in baseline mortality. When Tier 2 projects are included, the in-combination collision risk mortality is 179, which represents 0.2% of the pSPA population and a 1.4% increase in baseline mortality.

Conclusion

8.7.2.13 Further discussion of the appropriate parameters to be used in the analysis and modelling of likely mortality of the effects of wind farms on the breeding population of kittiwake will be undertaken through the Evidence Plan process. The appropriate way to assess the implications of predicted mortality on reference populations will also be explored and agreed through the Evidence Plan process. The expectation however is that Population Viability Analysis (PVA) modelling outputs will be used to assess the significance of the predicted mortality impacts from collision on kittiwake which breed at the colony which comprise the Flamborough and Filey Coast (FFC) pSPA. The population models will be those already undertaken for Hornsea Project Two (SMart Wind 2015).

Table 8.22: Predicted in-combination collision mortality for kittiwake[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	124	81	83	67	37	5.4	2	6	7.1	0
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	18				1	5.4	0	2	7.1	0
Blyth Demonstration Project	Band (2011)	1	99.2	4	1	100	1	2	5.4	0	1	7.1	0
Dogger Bank Creyke Beck Projects A and B	Band (2012)	3	98	218	87	19	17	41	5.4	2	90	7.1	6
Dogger Bank Teesside Projects A and B	Band (2012)	3	98	135				27	5.4	1	16	7.1	1
Dudgeon	Band (2000)	1	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				11	5.4	1	6	7.1	0
Hornsea Project One	Band (2012)	4	98	21	8	83	7	9	5.4	0	4	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	6	2	100	2	2	5.4	0	1	7.1	0
Inch Cape	Band (2012)	1	99.2	219				163	5.4	9	45	7.1	3
Kentish Flats	Band (2012)	1	98.9	2				1	5.4	0	0	7.1	0

[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
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				2	5.4	0	1	7.1	0
Moray Firth Project One (MORL)	Band (2012)	3	98	43				2	5.4	0	6	7.1	0
Neart na Gaoithe	Band (2012)	1	99.2	68				41	5.4	2	1	7.1	0
Race Bank	Band (2000)	1	99.2	23	1	100	1	17	5.4	1	4	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
Teesside	Band (2000)	1	99.2	56				17	5.4	1	2	7.1	0
Thanet	Band (2000)	1	99.2	1				0	5.4	0	0	7.1	0
Triton Knoll	Band (2000)	1	99.2	152	18	100	18	101	5.4	5	33	7.1	2
Westermost Rough	Band *et al.* (2007)	1	99.2	0	0	100	0	0	5.4	0	0	7.1	0
Tier 1 total							116			35			23
Tier 2													
East Anglia Three	Band (2012)	3	98	89				54	5.4	3	25	7.1	2
Overall total							116			38			25

Puffin

Operations/maintenance

Displacement

8.7.2.14 There is no predicted mortality of puffin associated with the breeding colony of the Flamborough and Filey Coast pSPA as a result of displacement from Hornsea Three in any biological season. There is, therefore, no indication of an adverse effect on the puffin breeding feature at Flamborough and Filey Coast pSPA as a result of disturbance or displacement due to operation and maintenance activities either alone or in-combination with other plans and projects.

Razorbill

Operations/maintenance

Displacement

8.7.2.15 There is no predicted mortality of razorbill associated with the breeding colony of the Flamborough and Filey Coast pSPA as a result of displacement from Hornsea Three in any biological season. There is, therefore, no indication of an adverse effect on the razorbill breeding feature at Flamborough and Filey Coast pSPA as a result of disturbance or displacement due to operation and maintenance activities either alone or in-combination with other plans and projects.

Guillemot

Operations/maintenance

Disturbance/displacement

8.7.2.16 The predicted displacement of guillemot from other wind farm projects is summarised in Table 8.23 for the breeding and non-breeding seasons.

8.7.2.17 During the non-breeding season in-combination displacement arising from Tier 1 projects potentially affects 3,393 birds, which leads to (Table 8.24) mortality of 10 individuals (assuming displacement of 30% and mortality of 1%). If Tier 2 projects are included, the number of birds effected is 3,455, which leads to (Table 8.25) mortality of 10 individuals (assuming displacement of 30% and mortality of 1%). The predicted mortality comprises 0.012% of the breeding population and an increase in mortality of less than 0.2%.

8.7.2.18 It is assessed that there is no potential for an adverse effect on the integrity of the guillemot population of the Flamborough and Filey Coast pSPA as a result of disturbance / displacement effects of Hornsea Three alone or in-combination with other plans and projects.

Conclusion

8.7.2.19 Further discussion of the appropriate parameters to be used in the analysis and modelling of likely mortality of the effects of wind farms on the breeding population of guillemot will be undertaken through the Evidence Plan process. The appropriate way to assess the implications of predicted mortality on reference populations will also be explored and agreed through the Evidence Plan process. The expectation however is that Population Viability Analysis (PVA) modelling outputs will be used to assess the significance of the predicted mortality impacts from displacement on guillemot which breed at the colony which comprise the Flamborough and Filey Coast (FFC) pSPA. The population models will be those already undertaken for Hornsea Project Two (SMart Wind 2015).

Table 8.23: Predicted in-combination displacement mortality for guillemot[11].

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	Mean-peak population apportioned to the pSPA in the non-breeding season
Hornsea Project Three		13164		4.4		581
Tier 1						
Aberdeen		225		4.4		10
Beatrice		2755		4.4		122
Blyth Demonstration	1220	1321	12.1	4.4	148	58
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		2268		4.4		100
Dogger Bank Teesside B		3701		4.4		163
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	13795	12.1	4.4	939	609
Humber Gateway	99	138	100	4.4	99	6
Inch Cape		3177		4.4		140
Lincs and LID6	582	814	100	4.4	582	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	100	4.4	361	31
Seagreen A		0		4.4		0
Seagreen B		0		4.4		0
Sheringham Shoal	390	715	12.1	4.4	47	32
Teesside	267	901	100	4.4	267	40

[11] Grey shading represents projects which fall outside of foraging range from SPA colonies and therefore no data is considered in the breeding season.

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	Mean-peak population apportioned to the pSPA in the non-breeding season
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					9659	3393
Tier 2						
East Anglia Three		1396		4.4		62
Overall total					9659	3455

Table 8.24: Predicted in-combination guillemot mortality from Flamborough and Filey Coast 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	3	7	17	34	68	102	136	170	204	238	271	305	339
20	7	14	34	68	136	204	271	339	407	475	543	611	679
30	10	20	51	102	204	305	407	509	611	713	814	916	1018
40	14	27	68	136	271	407	543	679	814	950	1086	1222	1357
50	17	34	85	170	339	509	679	848	1018	1188	1357	1527	1697
60	20	41	102	204	407	611	814	1018	1222	1425	1629	1832	2036
70	24	48	119	238	475	713	950	1188	1425	1663	1900	2138	2375
80	27	54	136	271	543	814	1086	1357	1629	1900	2172	2443	2715
90	31	61	153	305	611	916	1222	1527	1832	2138	2443	2748	3054
100	34	68	170	339	679	1018	1357	1697	2036	2375	2715	3054	3393

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

Table 8.25: Predicted in-combination guillemot mortality from Flamborough and Filey Coast 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	3	7	17	35	69	104	138	173	207	242	276	311	345
20	7	14	35	69	138	207	276	345	415	484	553	622	691
30	10	21	52	104	207	311	415	518	622	725	829	933	1036
40	14	28	69	138	276	415	553	691	829	967	1106	1244	1382
50	17	35	86	173	345	518	691	864	1036	1209	1382	1555	1727
60	21	41	104	207	415	622	829	1036	1244	1451	1658	1866	2073
70	24	48	121	242	484	725	967	1209	1451	1693	1935	2176	2418
80	28	55	138	276	553	829	1106	1382	1658	1935	2211	2487	2764
90	31	62	155	311	622	933	1244	1555	1866	2176	2487	2798	3109
100	35	69	173	345	691	1036	1382	1727	2073	2418	2764	3109	3455

	< 1% background mortality		> 1% background mortality/>1% SPA population		> 1% SPA population

8.8 Summary

8.8.1.1 The screening process indicated that LSE on the interest features of the Greater Wash pSPA and Filey and Flamborough Coast pSPA could not be discounted and so a systematic assessment of the potential for an adverse effect on the integrity of this site has been undertaken.

8.8.1.2 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 site's Conservation Objectives.

8.8.1.3 With respect to both the Greater Wash pSPA and the Flamborough and Filey Coast pSPA, 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 those sites.

8.8.1.4 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.

8.8.1.5 In each case the distribution of qualifying features within each site will also be maintained.

8.8.1.6 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. With respect to the Greater Wash pSPA, there is no indication that the construction and operation of Hornsea Three alone and in-combination with other offshore wind farms will cause additional morality that would lead to an adverse effect on those populations.

8.8.1.7 With respect to the Flamborough and Filey Coast pSPA, there is no indication, at this stage, that the construction and operation of Hornsea Three alone and in-combination with other offshore wind farms will cause additional morality of puffin, razorbill or guillemot that would lead to an adverse effect on those populations. Indeed there are no predicted mortality of razorbill associated with the breeding colony of the Flamborough and Filey Coast pSPA as a result of displacement in any season from Hornsea Three, which in any case lies outside of foraging range from the colony in the breeding season. This conclusion would not be expected to change with the incorporation of further data from the aerial survey programme for Hornsea Three (paragraph 8.4.4.1). Whilst there is no indication that additional mortality of gannet and kittiwake arising from the project alone would lead to an adverse effect on those populations, further assessment of the in-combination effects on those breeding populations will be undertaken.

8.8.1.8 These conclusions are summarised in Table 8.26 below.

Table 8.26: Summary of conclusions: offshore ornithology

Site	Feature	Project phase	Potential Impact	Conclusion Project alone	Conclusion project in-combination with other plans and projects
Greater Wash pSPA	• Red-throated diver • Common scoter	Construction/ Decommissioning	• Disturbance	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
		Operation	• Displacement	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
Flamborough and Filey Coast pSPA	• Gannet	Operation	• Collision risk • Displacement	No adverse effect on site integrity predicted	Further assessment of the in-combination effects required
	• Kittiwake	Operation	• Collision risk	No adverse effect on site integrity predicted	Further assessment of the in-combination effects required
	• Puffin	Operation	• Displacement	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
	• Razorbill	Operation	• Displacement	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted
	• Guillemot	Operation	• Displacement	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted

9. Assessment of Adverse Effects on Integrity: onshore ecology

9.1 Introduction

9.1.1.1 The screening exercise (Stage 1 of the HRA process) identified potential for LSEs on the onshore ecology features of the sites listed in Table 9.1 and shown in Figure 9.1.

9.1.1.2 The Draft 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 will be submitted as part of the Application for Development Consent. The final assessment for each effect is based upon expert judgement.

9.2 Conservation Objectives

9.2.1.1 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.

9.3 Potential impacts

9.3.1.1 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 9.1 and shown in Figure 9.1.

9.4 Baseline information

9.4.1.1 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 9.1: European sites and features for which LSE have been identified onshore ecology.

<table>
<tr><th>Site</th><th>Feature</th><th>Project phase</th><th>Effect</th></tr>
<tr><td colspan="4">Annex I habitats</td></tr>
<tr><td rowspan="2">Norfolk Valley Fens SAC</td><td rowspan="2">• 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)</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td rowspan="2">Wensum River SAC</td><td rowspan="2">• Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation; Rivers with floating vegetation often dominated by water-crowfoot</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td rowspan="2">North Norfolk Coast SAC</td><td rowspan="2">• 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).</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td rowspan="2">North Norfolk Coast Ramsar Site</td><td rowspan="2">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.</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
</table>

<table>
<tr><th>Site</th><th>Feature</th><th>Project phase</th><th>Effect</th></tr>
<tr><td colspan="4">Annex II species</td></tr>
<tr><td rowspan="2">Norfolk Valley Fens SAC</td><td rowspan="2">• Narrow-mouthed whorl snail Vertigo angustior
• Desmoulin's whorl snail Vertigo moulinsiana</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td rowspan="2">Wensum River SAC</td><td rowspan="2">• Desmoulin`s whorl snail Vertigo moulinsiana
• White-clawed (or Atlantic stream) crayfish Austropotamobius pallipes
• Brook lamprey Lampetra planeri
• Bullhead Cottus gobio</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td rowspan="2">North Norfolk Coast SAC</td><td rowspan="2">• Otter Lutra lutra
• Petalwort Petalophyllum ralfsii</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td>• Operation</td><td>• Temporary disturbance/damage
• Accidental pollution
• Invasive non-native species</td></tr>
<tr><td colspan="4">Ornithology</td></tr>
<tr><td>North Norfolk Coast SPA</td><td>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:</td><td>• Construction/ Decommissioning</td><td>• Permanent habitat loss
• Temporary disturbance/damage
• Habitat fragmentation
• Accidental pollution
• Invasive non-native species</td></tr>
</table>

<table>
<tr><th>Site</th><th>Feature</th><th>Project phase</th><th>Effect</th></tr>
<tr><td></td><td>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, LapwingVanellus vanellus, Sanderling Calidris alba, Cormorant Phalacrocorax carbo.</td><td>Operation</td><td>Temporary disturbance/damage
Accidental pollution
Invasive non-native species</td></tr>
<tr><td rowspan="2">North Norfolk Coast Ramsar Site</td><td rowspan="2">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</td><td>Construction/ Decommissioning</td><td>Permanent habitat loss
Temporary disturbance/damage
Accidental pollution
Invasive non-native species</td></tr>
<tr><td>Operation</td><td>Temporary disturbance/damage
Accidental pollution
Invasive non-native species</td></tr>
</table>

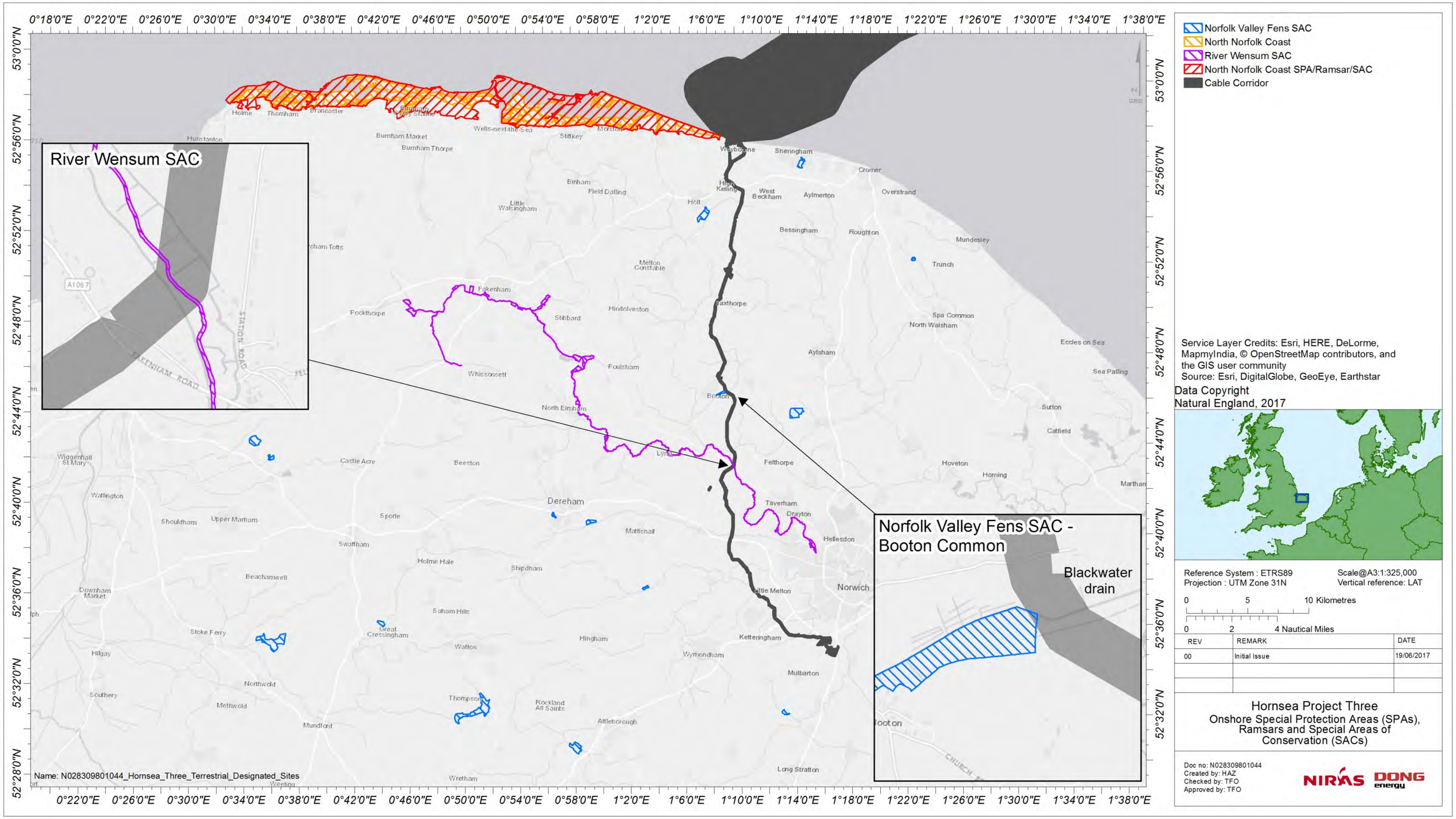

Figure 9.1: Onshore European sites identified for further assessment

9.5 Assessment on adverse effect on site integrity - Annex I Habitats

9.5.1 Norfolk Valley Fens SAC

Site Description

9.5.1.1 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*.

9.5.1.2 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.

9.5.1.3 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*.

9.5.1.4 The onshore cable corridor search area overlaps with 0.3 km^2 of the site at Booton Common, representing 4.9% of the total SAC site area (Figure 9.1).

Conservation Objectives

9.5.1.5 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

9.5.1.6 The features screened into the assessment include all Annex I habitats (see below) and Annex II species qualifying features (see section 9.6.2) in respect of all likely significant effects (Table 9.1).

Baseline

9.5.1.7 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the Norfolk Valley Fens SAC accounting for the location of the proposed HVAC booster and substations. An analysis of the distribution of Annex 1 habitat data for the area within the Norfolk Valley Fens SAC (Natural England, 2015) identified that alkaline fens (calcium-rich springwater-fed fens) occur within the onshore cable corridor search area at Booton Common.

9.5.1.8 The following Annex I habitats are not known to occur where the onshore cable corridor search area overlaps with 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).

9.5.1.9 As a result of the spatial separation, no adverse effect on site integrity is reasonably foreseeable with respect to the above listed Annex I habitats for any of the likely significant impact related to construction/decommissioning and operation.

Likely significant effects – construction/decommissioning

Alkaline fens (calcium-rich springwater-fed fens)

Permanent habitat loss

9.5.1.10 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of junction bays. It is proposed that direct impacts will be avoided by the application of the following design measures:

- Selection of cable route within the onshore cable corridor search area so that all installation occurs outside designated site boundaries; or
- Horizontal Directional Drilling (HDD), where the cable corridor cannot avoid a designated site.

9.5.1.11 In the absence of these measures the onshore cable corridor could result in the severance or impediment of ground water flows at Booton Common with the potential to create drier ground conditions. Changes in hydrological conditions are known to influence the extent and condition of alkaline fens (Šefferová, *et al*., 2008). Groundwater flows direct to the Blackwater Drain and the feeder channel rather than to Booton Common however the Blackwater Drain and Booton Common are likely to be hydrologically linked. Hydrological studies are currently on-going and will inform further consultation and updates to this Report to Inform Appropriate Assessment where applicable.

Conclusion

9.5.1.12 The proposed design measures will avoid any permanent habitat loss within the Norfolk Valley Fens SAC. The buried export cable is not likely to impact groundwater flows into the hydrologically linked Blackwater Drain and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting process on which the habitats rely.

Temporary disturbance/ damage

9.5.1.13 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the Norfolk Valley Fens SAC including the location of the HVAC booster and substations. Within the spatial overlap, alkaline fens (calcium-rich springwater-fed fens) occur at Booton Common.

9.5.1.14 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. As described above, it is proposed that direct impacts on the designated site will be avoided through design measures. Where HDD is used, temporary compounds of 70 m x 70 m will be located at either end of the HDD crossing and outside of the designated site.

9.5.1.15 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 designated site that the risk of temporary disturbance/damage will be minimised.

9.5.1.16 Where temporary haul routes pass through the designated site these will be subject to consultation with Natural England and revision of this Draft Report to Inform Appropriate Assessment .

Conclusion

9.5.1.17 The proposed design measures will avoid and minimise any temporary disturbance/damage within the Norfolk Valley Fens SAC and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or the supporting process on which the habitats rely.

Accidental pollution

9.5.1.18 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. Details of measures relating to pollution prevention will be described in the outline CoCP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

9.5.1.19 HDD is proposed at the Blackwater drain which is likely to be 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 minimise the risk of run-off from trenching reaching the river

Conclusion

9.5.1.20 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 this Annex I habitat within the Norfolk Valley Fens SAC. The employment of an Ecological Clark of Works (ECoW) will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens).

Invasive non-native species

9.5.1.21 The introduction of invasive non-native species from contaminated construction equipment 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, 2014a). To ensure that invasive non-native species are not spread to, from or within the Norfolk Valley Fens SAC, works will be carried out in accordance with relevant legislative requirements and applicable best practice guidelines and measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the EMP and CoCP.

Conclusion

9.5.1.22 The proposed application of industry best practice (i.e. known effective measures) 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 EMP and CoCP. Therefore no adverse effect on site integrity is reasonably foreseeable with respect to a change in extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting process on which the habitats rely.

Likely significant effects – operation

<u>Alkaline fens (calcium-rich springwater-fed fens)</u>

Temporary disturbance/damage

9.5.1.23 Operational maintenance of the 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. As described above, direct impacts on the designated site will be avoided and therefore operational activities will take place at either end of the HDD cable section and outside of the Norfolk Valley Fens SAC .

Conclusion

9.5.1.24 The proposed design measures will avoid any temporary disturbance/damage within the Norfolk Valley Fens SAC and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens) or to the supporting process on which the habitats rely.

Accidental pollution

9.5.1.25 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.

9.5.1.26 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 measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects .

Conclusion

9.5.1.27 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 EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of alkaline fens (calcium-rich springwater-fed fens).

9.5.2 River Wensum SAC

Introduction

9.5.2.1 The 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.

9.5.2.2 *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.

9.5.2.3 A section of the River Wensum SAC site which accounts for an area of 0.2 km^2 (representing 6.7% of the total area of the SAC site) overlaps with the onshore cable corridor search area (Figure 9.1).

Conservation Objectives

9.5.2.4 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

9.5.2.5 The features screened into the assessment include all Annex I habitats (see below) and Annex II species qualifying features (see section 9.6.3) in respect of all likely significant effects (Table 9.1).

Baseline

9.5.2.6 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the River Wensum SAC including the location of the HVAC booster and substations. Floating vegetation often dominated by water-crowfoot only occurs downstream of the point where the onshore cable corridor search area crosses the River Wensum; no Annex I habitats within the River Wensum SAC are known within the onshore cable corridor.

Likely significant effects – construction/ decommissioning

<u>Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (rivers with floating vegetation often dominated by water-crowfoot)</u>

Permanent habitat loss

9.5.2.7 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of junction bays. It is proposed that direct impacts will be avoided by the application of the following design measures:

- Horizontal Directional Drilling (HDD), where the cable corridor cannot avoid a designated site.

9.5.2.8 The 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

9.5.2.9 The 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 is reasonably foreseeable with respect to the extent, distribution, structure and function of this Annex I habitat within the River Wensum SAC or to the supporting process on which the habitats rely.

Temporary disturbance/damage

9.5.2.10 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.

9.5.2.11 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 minimise the risk of temporary disturbance/damage will be minimised.

9.5.2.12 Where practicable, haul routes will avoid crossing the River Wensum, Swannington Beck or, should crossing be unavoidable, employ silt traps or silt curtains downstream of the crossing points. 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.

9.5.2.13 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.

Conclusion

9.5.2.14 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 is reasonably foreseeable with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot or the supporting process on which the habitats rely.

Accidental pollution

9.5.2.15 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.

9.5.2.16 Details of measures relating to pollution prevention will be described in the outline CoCP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects .

9.5.2.17 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 .

Conclusion

9.5.2.18 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 EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot.

Invasive non-native species

9.5.2.19 The introduction of invasive non-native species from contaminated construction equipment 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 japonic*a are known to occur on the banks of the River Wensum (Natural England, 2014b). To ensure that invasive non-native species are not spread to, from or within the River Wensum SAC, works will be carried out in accordance with relevant legislative requirements and best practice guidelines and that measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP. An Ecological Clark of Works (ECoW) will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the EMP and CoCP.

Conclusion

9.5.2.20 The proposed application of industry best practice (i.e. known effective mitigation) 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 EMP and CoCP. Therefore, no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot or to the supporting processes on which it relies.

Likely significant effects – operation

Temporary disturbance/damage

9.5.2.21 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. An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the River Wensum SAC including the location of the HVAC booster and substations. Floating vegetation often dominated by water-crowfoot only occurs downstream of the onshore cable corridor crossing point with the River Wensum; no Annex I habitats within the River Wensum SAC are known within the onshore cable corridor.

9.5.2.22 Operational maintenance of the onshore cable 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. 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.

Conclusion

9.5.2.23 The proposed design measures will avoid any temporary habitat disturbance/damage within the River Wensum SAC and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot or the supporting process on which the habitats rely.

Accidental pollution

9.5.2.24 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.

9.5.2.25 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 measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects .

Conclusion

9.5.2.26 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 EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect the extent, distribution, structure and function of floating vegetation often dominated by water-crowfoot.

9.5.3 North Norfolk Coast SAC

Introduction

9.5.3.1 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.

9.5.3.2 Some of the slacks support the liverwort petalwort *Petalophyllum ralfsii*. In addition, the site supports otter *Lutra lutra*.

9.5.3.3 The onshore cable corridor is located approximately 0.5 km from the North Norfolk Coast SAC (Figure 9.1).

Conservation Objectives

9.5.3.4 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

9.5.3.5 The features screened into the assessment include all Annex I habitats (see below) and Annex II species qualifying features (see section 9.6.4) with respect to all likely significant effects (Table 9.1).

Baseline

9.5.3.6 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the North Norfolk Coast SAC including the location of the HVAC booster and substations. No Annex I habitats within the North Norfolk SAC are known within the onshore cable corridor search area.

Likely significant effects – construction/decommissioning/operation

Conclusion

9.5.3.7 The permanent and temporary footprint of the onshore cable corridor, associated infrastructure and haul routes are spatially separated from the North Norfolk Coast SAC (0.5 km) and its Annex I habitat qualifying features. There is no hydrological connection between the onshore cable corridor and the North Norfolk Coast SAC and therefore there is no reasonably foreseeable impact pathway. Furthermore, the spatial separation between the onshore cable corridor, the potential location for the introduction of invasive non-native species, and the SAC is sufficiently large to exclude reasonably foreseeable impact pathway. Therefore, no adverse effect on site integrity is reasonably foreseeable for construction/decommissioning and operation in respect of habitat loss, disturbance or damage.

9.5.4 North Norfolk Coast Ramsar

Introduction

9.5.4.1 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.

9.5.4.2 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.

9.5.4.3 The onshore cable corridor is located approximately 0.5 km from the North Norfolk Coast Ramsar (Figure 9.1).

Conservation Objectives

9.5.4.4 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.

9.5.4.5 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

9.5.4.6 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 9.1).

Baseline

9.5.4.7 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the North Norfolk Coast Ramsar including the location of the proposed HVAC booster and substations. The onshore cable corridor and the North Norfolk Coast Ramsar are spatially separated by 0.5 km, therefore no habitats of the North Norfolk Coast Ramsar are known within the onshore cable corridor search area.

Likely significant effects – construction/decommissioning/operation

Conclusion

9.5.4.8 The permanent and temporary footprint of the onshore cable corridor, associated infrastructure and haul routes are spatially separated from the North Norfolk Coast Ramsar site 0.5 km) and its habitats. There is no hydrological connection between the onshore cable corridor and the North Norfolk Coast SAC and therefore there is no reasonably foreseeable impact pathway. Furthermore, the spatial separation between the onshore cable corridor, the potential location for the introduction of invasive non-native species, and the Ramsar site is sufficiently large to exclude reasonably foreseeable impact pathway Therefore, no adverse effect on site integrity is reasonably foreseeable for construction/decommissioning and operation in respect of habitat loss, disturbance or damage.

9.6 Assessment of adverse effect on site integrity - Annex II species

9.6.1.1 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 9.1 and shown in Figure 9.1.

9.6.2 Norfolk Valley Fens SAC

9.6.2.1 An introduction to the Norfolk Valley Fens SAC and its Conservation Objectives is presented in section 9.5.1.

Features screened into assessment

9.6.2.2 The features screened into the assessment with respect to all likely significant effects are narrow-mouthed whorl snail *Vertigo angustior* and Desmoulin's whorl snail *V. moulinsiana* (Table 9.1).

Baseline

9.6.2.3 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the Norfolk Valley Fens SAC including the location of the proposed HVAC booster and substations. Within the spatial overlap, narrow-mouthed whorl snail and Desmoulin's whorl snail are known to occur at Booton Common, Detailed surveys are being conducted in 2017, the results of which together with consultation with Natural England will inform updates to this assessment.

Likely significant effects — construction/decommissioning

Desmoulin's whorl snail — Narrow-mouthed whorl snail

Permanent habitat loss

9.6.2.4 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of junction bays. It is proposed that direct impacts will be avoided by the application of the following design measures:

- Selection of cable route within the onshore cable corridor search area so that all installation occurs outside designated site boundaries; or
- Horizontal Directional Drilling (HDD), where the cable corridor cannot avoid a designated site.

9.6.2.5 Groundwater flows direct to the Blackwater Drain and the feeder channel rather than to Booton Common however the Blackwater Drain and Booton Common are likely to be hydrologically linked. Hydrological studies are currently on-going and will inform further consultation and updates to this Draft Report to Inform Appropriate Assessment where applicable.

Conclusion

9.6.2.6 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 is reasonably foreseeable 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

9.6.2.7 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.

9.6.2.8 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.

9.6.2.9 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 designated site that the risk of temporary disturbance/damage will be minimised.

9.6.2.10 Where temporary haul routes pass through the designated site these will be subject to consultation with Natural England and revision of this Draft Report to Inform Appropriate Assessment.

9.6.2.11 Where suitable habitat is located within the onshore cable corridor but outside the Norfolk Valley Fens SAC at Booton Common, translocation of individual snails into adjacent retained habitat will take place and habitat restoration will take place. This will allow re-colonisation once construction is complete. Given that the maximum design scenario involves a three-phase installation programme over a 11 year period, 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 three 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 onshore cable corridor.

Conclusion

9.6.2.12 The proposed design measures will avoid any temporary habitat disturbance/damage within the Norfolk Valley Fens SAC and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.6.2.13 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.

9.6.2.14 Details of measures relating to pollution prevention will be described in the outline CoCP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

9.6.2.15 HDD is proposed at the Blackwater drain which is hydrologically connected to Booton Common. 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

9.6.2.16 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 Norfolk Valley Fens SAC. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.6.2.17 Himalayan balsam *Impatiens glandulifera* is known to be present at Booton Common (Natural England, 2014a). 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 ensure that invasive non-native species are not spread to, from or within the Norfolk Valley Fens SAC it is proposed that works will be carried out in accordance with relevant legislative requirements and best practice guidelines and that measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP. An Ecological Clark of Works (ECoW) will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the EMP and CoCP.

Conclusion

9.6.2.18 The proposed application of industry best practice (i.e. known effective mitigation) 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 EMP and CoCP. Therefore no adverse effect on site integrity is reasonably foreseeable with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Likely significant effects — operation

<u>Desmoulin's whorl snail — Narrow-mouthed whorl snail</u>

Temporary disturbance/damage

9.6.2.19 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.

9.6.2.20 Operational maintenance of the 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. 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 Norfolk Valley Fens SAC. Where HDD is used, 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.

Conclusion

9.6.2.21 The proposed design measures will avoid any temporary habitat disturbance/damage within the Norfolk Valley Fens SAC and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.6.2.22 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.

9.6.2.23 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 measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

9.6.3 River Wensum SAC

9.6.3.1 An introduction to the River Wensum SAC and its Conservation Objectives is presented in section 9.5.1.24.

Features screened into assessment

9.6.3.2 Table 9.1 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

9.6.3.3 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the River Wensum SAC including the location of the HVAC booster and substations. Within the spatial overlap, Desmoulin's whorl snail is known to occur in the River Wensum SAC). Detailed surveys are being conducted in 2017 .

9.6.3.4 Both brook lamprey and bullhead are known to occur within the River Wensum SAC and are assumed to be present within the onshore cable corridor search area.

9.6.3.5 White-clawed crayfish are historically known from the River Wensum however the presence of signal crayfish *Pacifastacus leniusculus* means that the population is now restricted to an area upstream of the onshore cable corridor and is unlikely to be affected (David White, Norfolk County Council, Onshore Ecology Expert Working Group, 17 February 2016). White-clawed crayfish are known to be eliminated by competitive competition with signal crayfish within three or four years of populations mixing (Holdich, 2003). Signal crayfish have been known in the River Wensum downstream of Lenwade Mill since at least 2010 (Natural England, 2010). On this basis of the likely absence of white-clawed crayfish from the River Wensum SAC, no adverse effect on site integrity is reasonably foreseeable for likely significant effects related to construction/decommissioning and operation.

Likely significant effects — construction/decommissioning

Desmoulin's whorl snail — Brook lamprey — Bullhead

Permanent habitat loss

9.6.3.6 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of junction bays. It is proposed that direct impacts will be avoided by the application of the following design measures:

- Horizontal Directional Drilling (HDD), where the cable corridor cannot avoid a designated site.

9.6.3.7 The 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. The location of the ducts has been selected based on site visits to identify appropriate locations for the ducts and temporary works areas that are outside habitats with potential to support protected species. 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

9.6.3.8 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, brook lamprey and bullhead. Furthermore, no likely hydrological effects have been identified that may impact the water levels within the River Wensum that support brook lamprey and bullhead or adjacent wet habitats supporting Desmoulin's whorl snail. On this basis no adverse effect on site integrity is reasonably foreseeable 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

9.6.3.9 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.

9.6.3.10 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.

9.6.3.11 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 designated site that the risk of temporary disturbance/damage will be minimised.

9.6.3.12 Where temporary haul route pass through the designated site these will be subject to consultation with Natural England and revision of this Draft Report to Inform Appropriate Assessment.

9.6.3.13 Where suitable habitat is located within the onshore cable corridor but outside the River Wensum, translocation of individual snails into adjacent retained habitat will take place and habitat restoration will take place. This will allow re-colonisation once construction is complete. Given that the maximum design scenario involves a three-phase installation programme over a 11 year period, 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 three 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 onshore cable corridor. The results of on-going surveys will inform consultation with Natural England and updates to this Draft Report to Inform Appropriate Assessment. Where no suitable habitat is found, construction will be unconstrained in relation to Desmoulin's whorl snail.

Conclusion

9.6.3.14 The proposed design measures will avoid any temporary habitat disturbance/damage within the River Wensum SAC that supports 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 is reasonably foreseeable 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

9.6.3.15 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.

9.6.3.16 Details of measures relating to pollution prevention will be described in the outline CoCP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

9.6.3.17 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.

Conclusion

9.6.3.18 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 and adjacent wet habitats. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.6.3.19 Himalayan balsam *Impatiens glandulifera* and Japanese knotweed *Fallopia japonica* are known to occur on the banks of the River Wensum (Natural England, 2014b). 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 ensure that invasive non-native species are not spread to, from or within the River Wensum SAC it is proposed that works will be carried out in accordance with relevant legislative requirements and best practice guidelines and that measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the EMP and CoCP.

Conclusion

9.6.3.20 The proposed application of industry best practice (i.e. known effective measures) 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 EMP and CoCP. Therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Likely significant effects — operation/maintenance

Desmoulin's whorl snail — Brook lamprey — Bullhead

Temporary disturbance/damage

9.6.3.21 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.

9.6.3.22 Operational maintenance of the 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. As described above, it is proposed that direct impacts on the designated site will be avoided and therefore operational activities will take place either end of the HDD cable section and outside of the River Wensum SAC.

Conclusion

9.6.3.23 The proposed design measures will avoid any temporary habitat disturbance/damage within the River Wensum SAC that supports 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 is reasonably foreseeable 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

9.6.3.24 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.

9.6.3.25 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 measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

9.6.3.26 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 and adjacent wet habitats. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

9.6.4 North Norfolk Coast SAC

9.6.4.1 An introduction to the North Norfolk Coast SAC and its Conservation Objectives is presented in section 9.5.3.

Features screened into assessment

9.6.4.2 The features screened into the assessment are petalwort *Petalophyllum ralfsii* and otter *Lutra lutra* (Table 9.1).

Baseline

9.6.4.3 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the North Norfolk Coast SAC including the location of the proposed HVAC booster and substations. Otters have been recorded off Sheringham Road near Weybourne.

9.6.4.4 The permanent and temporary footprint of the onshore cable corridor, associated infrastructure and haul routes are spatially separated (0.5 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 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 is reasonably foreseeable for construction/decommissioning and operation in respect of habitat loss and disturbance or damage to petalwort.

Likely significant effects — construction/decommissioning

Otter

Permanent habitat loss

9.6.4.5 Permanent habitat loss will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of junction bays. 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 .

9.6.4.6 A method statement detailing pre-construction measures and post-construction habitat restoration and management designed to ensure the protection of otter within the onshore cable corridor will be agreed with NE prior to the commencement of works .

9.6.4.7 Himalayan balsam and Japanese knotweed *Fallopia japonica* are known to occur within the onshore cable corridor search area. To ensure that invasive non-native species are not spread to, from or within the watercourses supporting otter it is proposed that works will be carried out in accordance with relevant legislative requirements and best practice guidelines and that measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP.

Conclusion

9.6.4.8 The proposed design and pre-construction measures will avoid permanent habitat loss in the North Norfolk Coast SAC and functionally linked land associated with the otter population of the North Norfolk Coast SAC. Furthermore, the construction measures in accordance with best practice, will effectively minimise the risk of spreading diseases and invasive non-native species. Therefore no adverse effect on site integrity is reasonably foreseeable 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

9.6.4.9 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.

9.6.4.10 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the North Norfolk Coast SAC including the location of the proposed HVAC booster and substations.

A method statement detailing pre-construction measures to ensure the protection of otter within the onshore cable corridor will be agreed with NE prior to the commencement of works.

9.6.4.11 Where considered necessary by the ECoW, high visibility fencing will be erected around works-free zones. 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.

9.6.4.12 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

9.6.4.13 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 is reasonably foreseeable 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

9.6.4.14 Habitat fragmentation will occur where natural or semi-natural habitats are replaced with concrete and other manmade materials, e.g. at the location of junction bays. An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the North Norfolk Coast SAC including the location of the proposed HVAC booster and substations. Otters have been recorded off Sheringham Road near Weybourne.

9.6.4.15 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 known otter holts and other resting places.

A method statement detailing pre-construction measures to ensure the protection of otter within the onshore cable corridor will be agreed with NE prior to the commencement of works.

9.6.4.16 Where considered necessary by the ECoW, high visibility fencing will be erected around works-free zones. 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.

Conclusion

9.6.4.17 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 in accordance with best practice, will effectively minimise the risk of spreading diseases and invasive non-native species. Therefore no adverse effect on site integrity is reasonably foreseeable with respect to otter 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

9.6.4.18 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.

9.6.4.19 Details of measures relating to pollution prevention will be described in the outline CoCP which will accompany the final DCO application. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects).

Conclusion

9.6.4.20 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 North Norfolk Coast SAC. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect to the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

Likely significant effects — operation/maintenance

<u>Otter</u>

Temporary disturbance/damage

9.6.4.21 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.

9.6.4.22 An assessment of LSE was based on the spatial overlap between the onshore cable corridor search area and the North Norfolk Coast SAC including the location of the HVAC booster and substations.

9.6.4.23 Operational maintenance of the 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. 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 SAC. Any operational activities over and above inspections will be subjected to the legal protection afforded to otter as a European Protected Species (EPS). Advice will be sought from an experienced otter ecologist and NE as to the requirement for an EPS licence, prior to the commencement of operational works.

Conclusion

9.6.4.24 The proposed design measures will avoid any temporary disturbance/damage to the North Norfolk Coast SAC otter population and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.6.4.25 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.

9.6.4.26 Details of measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

9.6.4.27 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 North Norfolk Coast SAC. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable with respect the extent and distribution of the Annex II species and the extent, distribution, structure and function of their supporting habitats.

9.7 Assessment of adverse effect on site integrity - ornithology

9.7.1.1 The screening exercise (Stage 1 of the HRA process) identified potential for LSEs on the terrestrial ornithology features of the sites listed in Table 9.1 and shown in Figure 9.1.

9.7.2 North Norfolk Coast SPA

Introduction

9.7.2.1 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.

9.7.2.2 The site is located east of The Wash on the northern coastline of Norfolk, eastern England. The onshore cable corridor search area overlaps with a small area of the eastern section of the site and 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 onshore cable corridor search area for onshore works and 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 and the colony features.

9.7.2.3 The onshore cable corridor is located approximately 0.5 km from the North Norfolk Coast SPA (Figure 9.1).

Conservation Objectives

9.7.2.4 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 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

9.7.2.5 All qualifying features, except tern species and Mediterranean gull are screened into the assessment with respect to all likely significant effects (Table 9.1).

Baseline

9.7.2.6 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 3.1: Onshore Ornithology – Wintering Survey Report). 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 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.

9.7.2.7 The maximum count of pink-footed geese recorded during the survey 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.

9.7.2.8 The area most frequented by the birds comprised beet fields north east of Weybourne. The cable corridor search area runs through the western edge of the area used by the birds and also through another field immediately south of Kelling Heath where 9,000 birds were recorded on one occasion.

9.7.2.9 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.

9.7.2.10 Located over 500 m outside the onshore cable corridor search area, 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.

9.7.2.11 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)).

9.7.2.12 Breeding bird surveys are currently on-going but no records of breeding qualifying features have to date been recorded within the onshore cable corridor.

Likely significant effects – construction/decommissioning

Permanent habitat loss

9.7.2.13 Permanent habitat loss will occur where arable fields (functionally linked land) are replaced with concrete and other manmade materials, e.g. at the location of junction bays. 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 junction bays spaced at least 750 m apart with an associated 3 m x 3 m link box at each junction bay.

9.7.2.14 The associated habitat loss within the functionally linked land area between Weybourne and Kelling Heath resulting from the man hole access to the junction bays and link boxes is to be determined but it is not likely to be significant with respect to the total area of functionally linked land available in any one year.

9.7.2.15 Access to the link boxes, jointing pits and transition joint bays will be via existing roads, tracks and field gates.

Conclusions

9.7.2.16 The proposed design measures 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 land available in any one year. Therefore no adverse effect on site integrity is reasonably foreseeable with respect to the population and distribution of the pink-footed goose.

Temporary habitat loss

9.7.2.17 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 9.7.2.20 below). The proposed design measures including wherever possible 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 land area 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 is 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

9.7.2.18 No adverse effect on site integrity is reasonably foreseeable 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 onshore cable corridor.

Temporary disturbance

9.7.2.19 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 (open trenching) activities being proposed, i.e. narrow, linear working corridor using machinery generating noise predominantly of a steady state rather than of an impulsive character.

9.7.2.20 Subject to site conditions and landowner permission at the time of construction, the option to avoid temporary disturbance will be considered. This could be achieved effectively by implementing the use of measures to displace birds from the post-harvest sugar beet tops (crown and leaves) within 500 m of construction activity on functionally linked land, i.e. between Weybourne and Kelling Heath. Measures would be implemented between November and January and would include proven methods such as the installation of scarecrows, large fertiliser sacks and farm machinery, e.g. bowsers, to prevent significant numbers of birds from settling (RSPB, 2008). This would reduce the level of disturbance experienced by the birds by encouraging them to settle on land outside the effect zone, and hence reduce energy expenditure from repeated flushing from land on or adjacent to the cable corridor.. Temporary habitat loss as a result of displacement is discussed above in 9.7.2.17.

9.7.2.21 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 incorporated into the CoCP and EMP.

9.7.2.22 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.

Conclusions

9.7.2.23 The onshore cable corridor is approximately 0.5 km east of the North Norfolk Coast SPA and therefore disturbance is not likely to be significant because of the spatial separation.

9.7.2.24 Furthermore, functionally linked land in respect of pink-footed geese in the area between Weybourne to Kelling Heath will be avoided where practicable by scheduling trenching works to the period outside November to January inclusive.

9.7.2.25 The application of industry best practice guidance in respect of noise mitigation measures will minimise the risk of disturbance to other functionally linked land supporting small numbers of qualifying / assemblage features.

9.7.2.26 Therefore no adverse effect on site integrity is reasonably foreseeable with respect to the population and distribution of the pink-footed goose.

Accidental pollution

9.7.2.27 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. Details of measures relating to pollution prevention will be described in the outline CoCP which will accompany the final DCO application. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects .

Conclusion

9.7.2.28 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 functionally linked land. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.7.2.29 The introduction of invasive non-native species from contaminated construction equipment and imported materials can result in the replacement of native species and modification to habitat structure and function. To ensure that invasive non-native species are not spread to, from or within the functionally linked land it is proposed that works will be carried out in accordance with relevant legislative requirements and best practice guidelines and that measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the EMP and CoCP.

Conclusion

9.7.2.30 The proposed application of industry best practice (i.e. known effective mitigation) will minimise the risk of introducing or spreading invasive non-native plant or animal species within the functionally linked land and adjacent wet habitats and the employment of an ECoW will ensure compliance with the EMP and CoCP. Therefore no adverse effect on site integrity is reasonably foreseeable 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.

Likely significant effects – operation and maintenance

Temporary habitat loss

9.7.2.31 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 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. 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.

9.7.2.32 On functionally linked land, disturbance is likely to occur during the period November to January inclusive. Regular inspection and maintenance activities for junction bays and link boxes within the functionally linked land area between Weybourne and Kelling Heath should be programmed to occur outside of this period. Where emergency works are required within the period November to January inclusive then a method statement for such instances with ecological supervision should be employed to minimise any temporary disturbance.

Conclusion

The proposed design and operational measures will avoid any temporary disturbance within the North Norfolk Coast SPA site and avoid and minimise temporary disturbance in functionally linked land, therefore, no adverse effect on site integrity is reasonably foreseeable with respect to the population and distribution of pink-footed goose

Accidental pollution

9.7.2.33 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. Details of measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects .

Conclusion

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 functionally linked land. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable 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.

9.7.3 North Norfolk Coast Ramsar

Introduction

9.7.3.1 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.

9.7.3.2 The onshore cable corridor is located approximately 0.5 km from the North Norfolk Coast Ramsar.

Conservation Objectives

9.7.3.3 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.

9.7.3.4 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.

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 likely significant effects (Table 9.1).

Baseline

9.7.3.5 Taking into account both the complete spatial overlap and the commonality of the qualifying features between the North Norfolk Coast and North Norfolk Coast Ramsar site, the baseline is described above in section 9.7.2.

Likely significant effects – construction/decommissioning

Permanent habitat loss

9.7.3.6 Permanent habitat loss will occur where arable fields (functionally linked land) are replaced with concrete and other manmade materials, e.g. at the location of junction bays. The proposed design measures will avoid permanent habitat loss within the North Norfolk Coast Ramsar. 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 junction bays spaced at least 750 m apart with an associated 3 m x 3 m link box at each junction bay.

9.7.3.7 The associated habitat loss within the functionally linked land area between Weybourne and Kelling Heath resulting from the man hole access to the junction bays and link boxes is to be determined but it is not likely to be significant with respect to the total area of functionally linked land available in any one year.

9.7.3.8 Access to the link boxes, jointing pits and transition joint bays will be via existing roads, tracks and field gates.

Conclusions

9.7.3.9 The proposed design measures 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 land available in any one year. Therefore no adverse effect on site integrity is reasonably foreseeable with respect to the population and distribution of pink-footed goose.

Temporary habitat loss

9.7.3.10 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; or the covering of sugar beet by trackway, equipment and stored materials. The proposed design measures 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 land area 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 is 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

9.7.3.11 No adverse effect on site integrity is reasonably foreseeable 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 onshore cable corridor.

Temporary disturbance

9.7.3.12 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 (open trenching) activities being proposed, i.e. narrow, linear working corridor using machinery generating noise predominantly of a steady state rather than of an impulsive character.

9.7.3.13 Subject to site conditions and landowner permission at the time of construction, the option to avoid temporary disturbance will be considered. This could be achieved effectively by implementing the use of measures to displace birds from the post-harvest sugar beet tops (crown and leaves) within 500 m of construction activity on functionally linked land, i.e. between Weybourne and Kelling Heath. Measures would be implemented between November and January and would include proven methods such as the installation of scarecrows, large fertiliser sacks and farm machinery, e.g. bowsers, to prevent significant numbers of birds from settling (RSPB, 2008). This would reduce the level of disturbance experienced by the birds by encouraging them to settle on land outside the effect zone, and hence reduce energy expenditure from repeated flushing from land on or adjacent to the cable corridor. Temporary habitat loss as a result of displacement is discussed above.

9.7.3.14 To minimise the risk of disturbance at all other 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 incorporated into the CoCP and EMP.

9.7.3.15 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.

Conclusions

9.7.3.16 The onshore cable corridor is approximately 0.5 km east of the North Norfolk Coast SPA and therefore disturbance is not likely to be significant because of the spatial separation.

9.7.3.17 Furthermore, functionally linked land in respect of pink-footed geese in the area between Weybourne to Kelling Heath will be avoided where practicable by scheduling trenching works to the period outside November to January inclusive.

9.7.3.18 The application of industry best practice guidance in respect of noise mitigation measures will minimise the risk of disturbance to other functionally linked land supporting small numbers of qualifying / assemblage features.

Therefore no adverse effect on site integrity is reasonably foreseeable with respect to the population and distribution of the pink-footed goose.

Accidental pollution

9.7.3.19 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. Details of measures relating to pollution prevention will be described in the outline CoCP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

9.7.3.20 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 functionally linked land. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable 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

9.7.3.21 The introduction of invasive non-native species from contaminated construction equipment and imported materials can result in the replacement of native species and modification to habitat structure and function. To ensure that invasive non-native species are not spread to, from or within the functionally linked land it is proposed that works will be carried out in accordance with relevant legislative requirements and best practice guidelines and that measures to prevent the transfer of invasive plant or animal species will be included in the EMP and CoCP. An ECoW will be employed for the duration of the enabling and construction phase to ensure compliance with measures included in the EMP and CoCP.

Conclusion

9.7.3.22 The proposed application of industry best practice (i.e. known effective mitigation) will minimise the risk of introducing or spreading invasive non-native plant or animal species within the functionally linked land and adjacent wet habitats and the employment of an ECoW will ensure compliance with the EMP and CoCP. Therefore no adverse effect on site integrity is reasonably foreseeable 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.

Likely significant effects – operation and maintenance

Temporary habitat loss

9.7.3.23 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; or the covering of sugar beet by trackway, equipment and stored materials. Operational maintenance of the 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. 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.

9.7.3.24 On functionally linked land, disturbance is likely to occur during the period November to January inclusive. Regular inspection and maintenance activities for junction bays and link boxes within the functionally linked land area between Weybourne and Kelling Heath should be programmed, where practicable, to occur outside of this period. Where emergency works are required within the period November to January inclusive then a method statement for such instances with ecological supervision should be employed to minimise any temporary disturbance.

Conclusion

The proposed design and operational measures will avoid any temporary disturbance within the North Norfolk Coast Ramsar site and avoid and minimise temporary disturbance in functionally linked land, therefore, no adverse effect on site integrity is reasonably foreseeable with respect to the population and distribution of pink-footed goose.

Accidental pollution

9.7.3.25 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. Details of measures relating to pollution prevention will be described in the outline an operational EMP. Measures will follow industry best practice guidance and include the provision of a pollution incident response plan and a drainage management plan to minimise potential pollution effects.

Conclusion

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 functionally linked land. The employment of an ECoW will ensure compliance with the EMP and CoCP and therefore no adverse effect on site integrity is reasonably foreseeable 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.

9.8 In-combination assessment methodology

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

9.8.1.1 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 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.

9.8.1.2 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 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 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 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;

- 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.

9.8.1.3 The specific projects scoped into this in-combination assessment and the Tiers into which these have been allocated, are outlined in Table 9.2. 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.

9.8.2 Maximum design scenarios

9.8.2.1 The maximum design scenarios identified in Table 9.2 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 (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.

9.8.2.2 Given that the main cabling works will result in temporary habitat loss rather than permanent habitat losses, it is considered that the potential for in-combination impacts is restricted to in-combination effects of habitat loss or disturbance to species in the event that the construction period for developments included in the in-combination assessment overlaps with cable installation. In this event there would be a greater potential for displacement or disturbance for species.

9.8.2.3 At present there is insufficient information on the timing of construction for the developments listed in Table 9.3 to be able to determine whether overlap with cabling works would occur. The maximum design scenario for Hornsea Three considered for this assessment is for three phases of with a maximum gap of four years between two of the three phases. There are therefore three potential windows for overlap with construction of developments close to the cable route.

Table 9.2: 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 leading to habitat loss and/or severance for a number of species	Tier 1 • Land off Rectory Road and Holt Road; • Land North And South Of Dereham Road; • Phase A1-A Land North Of Hethersett Village Centre; • Land South East Of The Gardens Mill Road; • Land North Of Gibbs Close; • Land South Of Ringwood Close; • Land South East Of The Gardens Mill Road; • Proposed Northern Distributor Road; • Land at Pitt Farm; • Mangreen Quarry, Swardeston; and • Land off Church Lane. Tier 2 • Norfolk Vanguard	Outcome of the CEA will be greatest when the greatest number of other schemes, present or planned, are considered.
Operation 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 1 • Land off Rectory Road and Holt Road; • Land North And South Of Dereham Road; • Phase A1-A Land North Of Hethersett Village Centre; • Land South East Of The Gardens Mill Road; • Land North Of Gibbs Close; • Land South Of Ringwood Close; • Land South East Of The Gardens Mill Road; • Proposed Northern Distributor Road; • Land at Pitt Farm; • Mangreen Quarry, Swardeston; and • Land off Church Lane. Tier 2 • Norfolk Vanguard	Outcome of the CEA will be greatest when the greatest number of other schemes, present or planned, are considered.

Potential impact	Maximum design scenario	Justification
Decommissioning phase		
Potential for decommissioning of cables to affect species	Tier 1 • Land off Rectory Road and Holt Road; • Land North And South Of Dereham Road; • Phase A1-A Land North Of Hethersett Village Centre; • Land South East Of The Gardens Mill Road; • Land North Of Gibbs Close; • Land South Of Ringwood Close; • Land South East Of The Gardens Mill Road; • Proposed Northern Distributor Road; • Land at Pitt Farm; • Mangreen Quarry, Swardeston; and • Land off Church Lane. Tier 2 • Norfolk Vanguard	Outcome of the CEA will be greatest when the greatest number of other schemes, present or planned, are considered.

9.9 Assessment of potential effect on site integrity in-combination with other plans and projects

9.9.1.1 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.

9.9.1.2 All Tier 1 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.

9.9.1.3 The proposed change of land use at Pitt Farm, Baconsthorpe from agricultural land to a 53 plot tent-only campsite has no overlapping construction phase (access) with Hornsea Three and therefore there are no reasonably foreseeable in-combination impact pathway to any European site including the Norfolk Valley Fens SAC approximately 2 km to the west.

9.9.1.4 The proposed Northern Distributor Road is due to be completed at the end of 2017 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.

9.9.1.5 In respect of Tier 2 developments, an in-combination e impact pathway exists between Hornsea Three and Norfolk Vanguard at Booton Common where the two cables routes are roughly perpendicular.

9.9.1.6 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 a similar timescale for the application to proceed through the planning system, it is possible that cabling works for both projects could be undertaken in the same approximate timescale, especially considering the maximum design scenario for Hornsea Three of a three-phase cabling operation over a 11 year period.

9.9.1.7 The results of Desmoulin's whorl snail surveys undertaken in 2017 will inform consultation with Natural England with regards to the extent of mitigation required for impacts alone and in-combination at Booton Common. At this stage, it is reasonably foreseeable that the translocation of narrow-mouthed and Desmoulin's whorl snails to a suitable receptor site outside the construction area followed by post-construction restoration of habitat to a like-for-like or better state would avoid in-combination effects.

9.9.1.8 At this stage, 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 9.3: List of other projects and plans 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
1	*Residential development*						
	Construction and Maintenance/ Decommissioning	Land North And South Of Dereham Road 2014/2611	0 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-Nov-16	Possible	Yes
	Construction and Maintenance/ Decommissioning	Phase A1-A Land North Of Hethersett Village Centre 2015/1594 and 2015/1681	133 m	Residential development of 95 dwellings with associated open space and infrastructure. Reserved matters for appearance, layout, and scale and landscaping of the first phase of development for 126 dwellings in relation to outline permission 2011/1804.	Approved 18-Dec-15 Reserved matters Approved 18-Feb-16	Possible	Yes
	Construction and Maintenance/ Decommissioning	Land South East Of The Gardens Mill Road 2015/2630	70 m	Residential Development for 8 dwellings, car parking and amenity space including 2 affordable dwellings which form part of planning reference 2015/0253.	Approved 30-Aug-16	Possible	Yes
	Construction and Maintenance/ Decommissioning	Land North Of Gibbs Close 2015/1697 and 2012/1836	295 m	Erection of 27 dwellings, access, roads, open space, parking areas and associated works. 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 27-Jun-16 Approved 29-Apr-14	Possible	Yes
	Construction and Maintenance/ Decommissioning	Land South Of Ringwood Close 2013/0092	1 m	Outline application for up to 20 residential units and associated highways works with all matters reserved.	Approved 20-Mar-14	Possible	Yes
	Construction and Maintenance/ Decommissioning	Land South East Of The Gardens Mill Road 2013/0086	70 m	Outline application including means of access for residential development and ancillary works.	Approved 30-Apr-14	Possible	Yes
	Change of land use						
	Operational	Land at Pitt Farm PF/12/1263	0 m	Change of use of land from agriculture to 53 units tent-only campsite and formation of vehicular access.	Approved 24/01/2013	No	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
	Commercial development						
		Mangreen Quarry, Swardeston 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-Oct-15	Yes	Yes
		Land off Church Lane 20170052	253 m	Greater Norwich Food Enterprise Zone	Pending Consideration (when checked on 02-Feb-17)	Possible	Yes
2	*Offshore wind farm*						
	Construction and Maintenance/ Decommissioning	Norfolk Vanguard EN010079	0 m	Norfolk Vanguard is a proposed offshore windfarm with an approximate capacity of 1800 MW off the coast of Norfolk.	Currently at Pre-Application Stage Application expected to be submitted to the PINS in Q2 2018	Yes	Yes

9.10 Summary

9.10.1.1 A summary of the conclusions of adverse effect on the integrity of the sites considered within in this section of the Draft Report to Inform Appropriate Assessment is provided in Table 9.4.

Table 9.4: 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)	• 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
	• 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).	• 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
		• Operation	• Temporary disturbance/damage • Accidental pollution • Invasive non-native species	No adverse effect on site integrity predicted	No adverse effect on site integrity predicted if there is co-ordination between Hornsea Three and Norfolk Vanguard with respect to construction activities near Booton Common
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

Site	Feature	Project phase	Effect	Conclusion Project alone	Conclusion project in-combination with other plans and projects
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
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*	• 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
	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	• 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
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	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

10. References

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, 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.

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

British Standards Institution (BSI) (2014a) British Standard 4142: Methods for rating and assessing industrial and commercial sound.

Brown, A. and Grice, P. (2005). Birds in England. London, Poyser.

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.

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) (2011c) Offshore Energy Strategic Environmental Assessment: OESEA2 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 of 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].

DONG Energy (2016) 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 (2017) Draft Report to Inform the Appropriate Assessment for Hornsea Three Offshore Wind Farm.

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.

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].

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).

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.

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.

GWFL (2011) Galloper Wind Farm Project Environmental Statement - Chapter 11: Offshore Ornithology.

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.

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.

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].

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. IMARES 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.

Joint Nature Conservation Committee (JNCC) (2012) Offshore Special Area of Conservation: North Norfolk Sandbanks and Saturn Reef. Conservation Objectives and Advice on Operations.

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].

Joint Nature Conservation Committee (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].

Joint Nature Conservation Committee (JNCC) (2014) Special Areas of Conservation (SAC) [Online]. Available at: http://jncc.defra.gov.uk/page-23. [Accessed 23 May 2017].

Joint Nature Conservation Committee (JNCC) (2015) Haisborough, Hammond and Winterton MPA. [Online] Available from:: http://jncc.defra.gov.uk/page-6534. [Accessed 23 May 2017].

Joint Nature Conservation Committee (JNCC) (2015) North Norfolk Sandbanks and Saturn Reef MPA. [Online] Available from:: http://jncc.defra.gov.uk/page-6537-theme=default. [Accessed 22 May 2017].

Joint Nature Conservation Committee (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 (2014). 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).

Jones, E.L. and Russell, D.J. (2017) Updated grey seal (*Halichoerus grypus*) usage maps in the North Sea. vol. OESEA-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.

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.

Langston, 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.

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.

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].

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].

MEAD, C. J. (1974) The results of ringing auks in Britain and Ireland. Bird Study 21: 45-86.

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.

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.

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.

Natural England (NE) (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 (NE) (2014) 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 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].

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, (2014a) Site Improvement Plan Norfolk Valley Fens. [pdf]. Avaialble from: <http://publications.naturalengland.org.uk/file/4592297601662976> [Accessed on 2 June 2017].

Natural England, (2014b) Site Improvement Plan River Wensum. [pdf]. Avaialble from: <http://publications.naturalengland.org.uk/file/5795274547003392> [Accessed on 2 June 2017].

Natural England, (2015) 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].

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].

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.

Oil and Gas UK (2015) UKbenthos Database. [Online] Available from: http://oilandgasuk.co.uk/product/ukbenthos/. [Accessed 22 May 2017].

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.

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.

Pennington, M., Osborn, K., Harvey, P., Riddington, R., Okill, D., Ellis, P. & Heubeck, M. 2004. The Birds of Shetland. Helm, A & C Black, London.

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 (2016) Habitats Regulations Assessment. [Online] Available from: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/06/Advice-note-10v4.pdf. [Accessed 23 May 2017].

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).

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.

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].

Scira Offshore Energy (2006) Sheringham Shoal offshore wind farm. Environmental Statement.

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.

Sea Mammal Research Unit (SMRU) (2011) Summary of seal count and telemetry data from the Humber area. Report to SMart Wind.

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.

SMP (2017). Online Database. Available at: http://www.jncc.gov.uk/smp/.

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., 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.

Tillin, H.M. (2016a) *Modiolus modiolus* beds on open coast 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/342/modiolus_modiolus_beds_on_open_coast_circalittoral_mixed_sediment. [Accessed 24 May 2017].

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, Brussel.

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.

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 (2005) Aerial surveys of waterbirds in strategic wind farm areas: winter 2004/05 – interim report. WWT report to Department of Trade and Industry. August 2005. 44pp.

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.