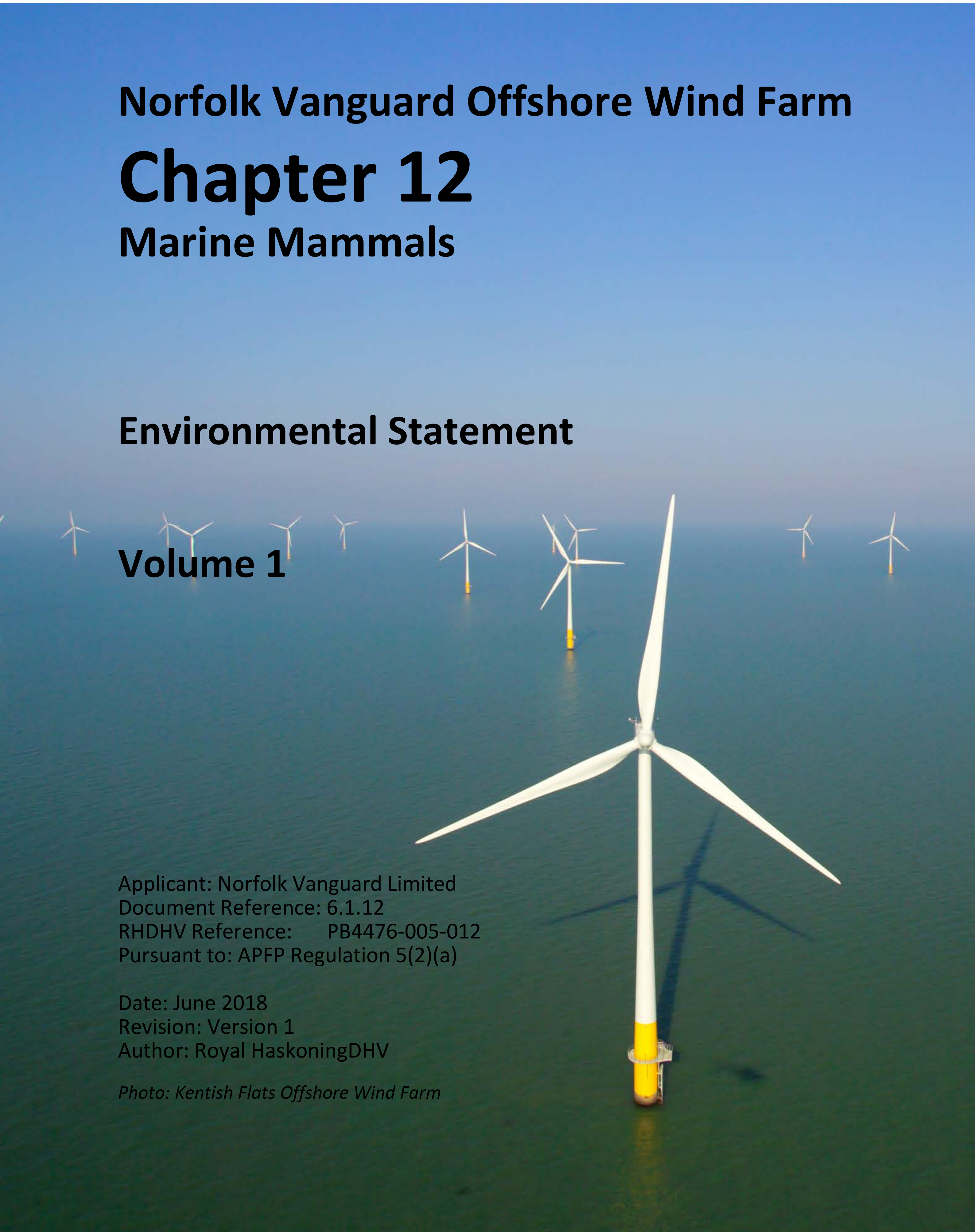
Norfolk Vanguard Offshore Wind Farm

Chapter 12

Marine Mammals

Environmental Statement

Volume 1



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For and on behalf of Norfolk Vanguard Limited

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Glossary

µPa	Micro pascal
ADD	Acoustic Deterrent Device
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
AU	Assessment Unit
AWAC	Acoustic Wave and Current
BAP	Biodiversity Action Plan
BGS	British Geological Survey
BSI	British Standards Institution
CBD	Convention on Biological Diversity
CCW	Countryside Council for Wales
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CGNS	Celtic and Greater North Sea
CI	Confidence Interval
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	Centimetre
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
CRoW	Countryside Rights of Way
cSAC	candidate Special Area of Conservation
CV	Confidence Variation
dB	Decibels
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DEPONS	Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea
DWR	Deep Water Routes
EA4	East Anglia FOUR
EAOW	East Anglia Offshore Wind
EATL	East Anglia THREE Ltd
EC	European Commission
EEZ	Exclusive Economic Zones
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EMP	Environmental Management Plan
EOD	Explosive Ordnance Disposal
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
FCS	Favourable Conservation Status
GBS	Gravity Base Structure

GC	Allied designation for German type LMB mine
GG	Allied designation for German type BM1000 mine
GNS	Greater North Sea
GS	Grey seal
GSD	Ground Sampling Distance
HE	High Explosive
HP	Harbour porpoise
HR	Habitats Regulations
HRA	Habitats Regulation Assessment
HS	Harbour seal
Hz	Hertz
IAMMWG	Inter-Agency Marine Mammal Working Group
IEEM	Institute for Ecology and Environmental Management
iPCoD	interim Population Consequences of Disturbance
IWC	International Whaling Commission
JCP	Joint Cetacean Protocol
JNCC	Joint Nature and Conservation Committee
kg	Kilogram
kJ	Kilojoule
km	Kilometre
Km^2	Kilometre squared
lb	Pound
LBAP	Local Biodiversity Action Plan
LiDAR	Light Detection and Ranging
LSE	Likely Significant Effect
m	Metre
m/s	Metres per second
MAREMAP	Marine Environment Mapping Programme
MATL	Marine Atlantic
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOs	Marine Mammal Observers
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
MYD	Marine Technology Directorate
MU	Management Unit
NEQ	Net Explosive Quantities
NPS	National Policy Statement
NS	North Sea
NSIP	Nationally Significant Infrastructure Project
nm	Nautical Miles
NMFS	National Marine Fisheries Services
NNR	National Nature Reserve
NOAA	National Oceanic and Atmospheric Administration

NPL	National Physical Laboratory
NPS	National Policy Statement
NS	North Sea
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
O&M	Operation and Maintenance
OMR	Offshore Marine Regulations
OSPAR	Oslo and Paris Convention for the Protection of the Marine Environment
OWF	Offshore Wind Farm
PDV	Phocine Distemper Virus
PE	Parabolic Equation
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
pSAC	proposed Special Area of Conservation
PTS	Permanent Threshold Shift
RMS	Root Mean Square
SAC	Special Area of Conservation
SEL	Sound Exposure Level
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCOS	Special Committee on Seals
SD	standard deviation
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SNS	Southern North Sea
SoS	Secretary of State
SPL	Sound Pressure Level
SST	Sea Surface Temperature
TNT	Trinitrotoluene
TSEG	Trilateral Seal Expert Group
TTS	Temporary Threshold Shift
TWT	The Wildlife Trust
UK	United Kingdom
UXO	Unexploded Ordnance
VWPL	Vattenfall Wind Power Limited
WDC	Whale and Dolphin Conservation
WS	West Scotland
WWT	Wetland and Water Trust
ZEA	Zonal Environmental Appraisal

Terminology

Array cables	Cables which link the wind turbines and the offshore electrical platform.
Interconnector cables	Buried offshore cables which link the offshore electrical platforms
Landfall	Where the offshore cables come ashore at Happisburgh South

Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead
Offshore cable corridor	The corridor of seabed from the Norfolk Vanguard OWF sites to the landfall site within which the offshore export cables would be located.
Offshore electrical platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which bring electricity from the offshore electrical platform to the landfall.
Offshore project area	The overall area of Norfolk Vanguard East, Norfolk Vanguard West and the offshore cable corridor.
Safety zone	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area under the Energy Act 2004.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Vanguard Limited.
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure.

12 MARINE MAMMALS

12.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the existing environment with regard to marine mammals which includes cetaceans (whales, dolphins and porpoises) and pinnipeds (seals) and assesses the potential impacts of the proposed Norfolk Vanguard project during the construction, operation and maintenance (O&M), and decommissioning phases. Where appropriate, mitigation measures and residual impacts are presented.

2. This assessment also considers information from, and refers to, the following chapters within the ES:

- Chapter 3 Policy and Legislative Context;
- Chapter 5 Project Description;
- Chapter 6 Environmental Impact Assessment (EIA) Methodology;
- Chapter 9 Marine Water and Sediment Quality;
- Chapter 11 Fish and Shellfish Ecology; and
- Chapter 15 Shipping and Navigation.

3. This chapter is supported by the following Appendices:

- Appendix 5.2 Ordtek Unexploded Ordnance (UXO) Review
- Appendix 5.3: Underwater Noise Modelling Report;
- Appendix 5.4 Underwater Noise modelling from UXO
- Appendix 12.1: Marine Mammal Survey Data and Correction Factors;
- Appendix 12.2: Effectiveness of ADDs as Mitigation for Marine Mammals;
- Appendix 12.3: Marine Mammal Cumulative Impact Assessment (CIA) screening;
- Appendix 12.4: Additional Assessment in relation to the potential Southern North Sea candidate Special Area of Conservation (SNS cSAC);
- Appendix 12.5: Additional Underwater Noise Assessments; and
- Appendix 12.6: Additional Cumulative Impact Assessment (CIA) Scenarios.

4. This chapter is also supported by the following documents:

- Consultation Report (document reference 5.1);
- Report to inform the Habitat Regulations Assessment (HRA) (document reference 5.3);
- Draft Marine Mammal Mitigation Protocol (MMMP) for piling (document reference 8.13) and
- In Principle Norfolk Vanguard Southern North Sea candidate Special Area of Conservation (cSAC) Site Integrity Plan (SIP) (document reference 8.17).

5. This chapter of the ES was written by Royal HaskoningDHV, and incorporates survey data collected by APEM Ltd and density estimates analysed by MacArthur Green which have been further interpreted in Appendix 12.1.

12.2 Legislation, Guidance and Policy

12.2.1 Legislation

12.2.1.1 The Habitats Directive

6. The European Union Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (hereafter called the Habitats Directive) gives regulation to the conservation and management of natural habitats, wild fauna (except birds) and flora in Europe. Its primary aim is to maintain or restore natural habitats and wild species at a favourable conservation status.

7. Annex II of the Habitats Directive lists species for which member states are expected to establish a "consistent network of special areas of conservation" as protected areas. Annex II includes several marine mammal species that occur in the United Kingdom (UK); harbour porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus* along with the grey seal *Halichoerus grypus* and harbour seal *Phoca vitulina*.

8. Although not legally binding, The Habitats Directive Article 12 Guidance (EC, 2007) states that:

> *"In order to assess a disturbance, consideration must be given to its effect on the conservation status of the species at population level and biogeographic level in a Member State. For instance, any disturbing activity that affects the survival chances, the breeding success or the reproductive ability of a protected species or leads to a reduction in the occupied area should be regarded as a "disturbance" in terms of Article 12."*

9. The Habitats Directive protects all species of cetaceans under Annex IV as European Protected Species (EPS), being classed as endangered, vulnerable or rare, and grey and harbour seals are protected under Annex V which requires their exploitation or removal from the wild to be subject to management measures. Harbour porpoise, bottlenose dolphin and both seal species are additionally listed under Annex II, which requires member states to designate sites, identified as being key areas for their life and reproduction, as Special Areas of Conservation (SACs).

10. Article 12 of the Habitats Directive requires member states to establish stricter protection for species within their natural range; prohibiting all forms of deliberate capture or killing, deliberate disturbance (particularly during breeding and rearing

periods, hibernations and migration) and the deterioration or destruction of breeding and resting sites.

12.2.1.2 The Conservation of Habitats and Species Regulations 2017

11. In November 2017, the Conservation of Habitats and Species Regulations 2010 (and amendments) were updated and consolidated into the Conservation of Habitats and Species Regulations 2017. In addition, the Conservation of Offshore Marine Habitats and Species Regulations 2017 update the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (collectively referred to as 'the Habitats Regulations 2017').

12. The Habitats Regulations 2017 transpose the Habitats Directive into national law. The Habitats Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment (AA) of any proposal likely to affect a Natura 2000 site, to seek advice from Statutory Nature Conservation Bodies (SNCBs) and to reject an application that would have an adverse effect on a Natura 2000 site except under very tightly constrained conditions that involve decisions by the Secretary of State. The competent authority in the case of the proposed project is the Secretary of State for Business Energy and Industrial Strategy (BEIS).

13. All cetacean species are listed under Schedule 2 and defined as EPS and all seals are listed under Schedule 4 (animals which may not be captured or killed in certain ways).

14. The Habitats Regulations deem it to be an offence if any of the following occur:

- Any species is deliberately captured, injured or killed with EPS status;
- Any wild species is deliberately disturbed;
- Any eggs of any wild species are deliberately taken or destroyed; and
- Any resting or breeding place of any wild animal is damaged or destroyed.

15. However, there is a provision to apply for an EPS licence where any of the above is expected to occur, only if it is deemed that there will be no long term detrimental effects. This is especially relevant to marine mammals and the likelihood of disturbance due to marine activities.

16. As in the Habitats Directive, there is a requirement to create SACs for species listed under Annex II; namely the harbour porpoise, bottlenose dolphin, grey and harbour seals and to advise on what marine operations my impact on their integrity.

17. There are a number of provisions within the regulations that protect marine species from harmful activities. EPS, as listed under Annex IV of the Habitats Directive, are protected from:

- The deliberate capture, injury, killing;
- Any disturbance that is likely to result in a significant impact to the ability of any species group to survive, breed, rear or impact, to disrupt a species' hibernation or migrations, or to affect significantly the local distributions and abundance of the species; and
- Damage or destroy any breeding or resting site.

18. The national legislation now more clearly transposes the requirement contained in the Habitats Directive to prohibit deliberate disturbance, and better reflect the circumstances in which disturbance may be particularly damaging to the animals concerned (as envisaged by Article 12). In addition, the Habitats Regulations provide for the offence of deliberate injuries.

12.2.1.3 Favourable Conservation Status (FCS)

19. In order to assess whether a disturbance could be considered 'non-trivial' in relation to the objectives of the Habitats Directive, consideration should be given to the definition of the FCS of a species given in Article 1(i) of the Habitats Directive. There are three parameters that determine when the Conservation Status of a species can be taken as favourable:

- Population(s) of the species is maintained on a long-term basis;
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
- The habitat on which the species depends (for feeding, breeding, rearing etc.) is maintained in sufficient size to maintain the population(s) over a period of years/decades.

20. Member states report back to the EU every six years on the Conservation Status of marine EPS. Table 12.1 shows that in the UK, four out of 11 cetacean species have been assessed as having an 'unknown' Conservation Status (based on the 2007-2012 reporting; Joint Nature and Conservation Committee (JNCC), 2013). This is a result of a lack of recent population[1] estimates that encompassed their natural range in UK and adjacent waters and / or having no evidence to determine long-term trends in population abundance.

21. Another 17 species were considered to be uncommon, rare or very rare in occurrence, so it was not possible to ascertain their Conservation Status. The seven

[1] 'Population' is defined in the EC guidance on the strict protection of animal species as a group of individuals of the same species living in a geographic area at the same time that are (potentially) interbreeding (i.e. sharing a common gene pool)

species outlined in Table 12.1 as having a 'favourable' Conservation Status, are underpinned by an assessment of moderate to low reliability. It can be interpreted that:

- A greater understanding of the species / population(s), or the factors affecting it, is required before a confident concluding judgement can be made by experts; and
- The current estimate of population and / or trends is based on recent, but incomplete or limited survey data, or based predominately on expert opinion.

22. Table 12.1 presents the Conservation Status of commonly occurring cetacean species within UK waters (JNCC, 2013).

Table 12.1 FCS assessment of cetacean species in Annex IV of the Habitats Directive occurring in UK and adjacent waters (JNCC, 2013)

Species	FCS assessment
Harbour porpoise *Phocoena phocoena*	Favourable
Minke whale *Balaenoptera acutorostrata*	Favourable
Fin whale *Balaenoptera physalus*	Favourable
Common dolphin Delphinus *delphis*	Favourable
Long-finned pilot whale *Globicephala melas*	Unknown
Risso's dolphin *Grampus griseus*	Unknown
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Favourable
Killer whale *Orcinus orca*	Unknown
White-beaked dolphin *Lagenorhynchus albirostris*	Favourable
Sperm whale *Physeter macrocephalus*	Unknown
Bottlenose dolphin *Tursiops truncatus*	Favourable

12.2.1.4 Summary of relevant legislation

23. Table 12.2 provides an overview of national and international legislation in relation to marine mammals.

Table 12.2 National and international legislation in relation to marine mammals

Legislation	Level of Protection	Species included	Details
Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)	International	Odontocetes	Formulated in 1992, this agreement has been signed by eight European countries bordering the Baltic and North Seas (including the English Channel) and includes the United Kingdom (UK). Under the Agreement, provision is made for the protection of specific areas, monitoring, research, information exchange, pollution control and increasing public awareness of small cetaceans.
The Berne Convention 1979	International	All cetaceans, grey seal *Halichoerus grypus* and harbour seal *Phoca vitulina*	The Convention conveys special protection to those species that are vulnerable or endangered. Appendix II (strictly protected fauna): 19 species of cetacean. Appendix III (protected fauna): all remaining cetaceans, grey and harbour seal. Although an international convention, it is implemented within the UK through the Wildlife and Countryside Act 1981 (with any aspects not implemented via that route brought in by the Habitats Directive).
The Bonn Convention 1979	International	All cetaceans	Protects migratory wild animals across all, or part of their natural range, through international co-operation, and relates particularly to those species in danger of extinction. One of the measures identified is the adoption of legally binding agreements, including ASCOBANS.
Oslo and Paris Convention for the Protection of the Marine Environment 1992(OSPAR)	International	Bowhead whale *Balaena mysticetus*, northern right whale *Eubalaena glacialis*, blue whale *Balaenoptera musculus*, and harbour porpoise *Phocoena*	OSPAR has established a list of threatened and/or declining species in the North East Atlantic. These species have been targeted as part of further work on the conservation and protection of marine biodiversity under Annex V of the OSPAR Convention. The list seeks to complement, but not duplicate, the work under the EC Habitats and Birds directives and measures under the Berne Convention and the Bonn Convention.
International Convention for the Regulation of Whaling 1956	International	All cetacean species	This Convention established the International Whaling Commission (IWC) who regulates the direct exploitation and conservation of large whales (in particular sperm and large baleen whales) as a resource and the impact of human activities on cetaceans. The regulation considered scientific matters related to small cetaceans, in particular the enforcing a moratorium on commercial whaling which came into force in 1986.

Legislation	Level of Protection	Species included	Details
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1975	International	All cetacean species	Prohibits the international trade in species listed in Annex 1 (including sperm whales, northern right whales, and baleen whales) and allows for the controlled trade of all other cetacean species.
Convention on Biological Diversity (CBD) 1993	International	All marine mammal species	Requires signatories to identify processes and activities that are likely to have impacts on the conservation of and sustainable use of biological diversity, inducing the introduction of appropriate procedures requiring an EIA and mitigation procedures.
The Conservation of Habitats and Species Regulations 2017 & The Conservation of Offshore Marine Habitats and Species Regulations 2017	National	All cetaceans, grey and harbour seal	In November 2017, in England and Wales the Conservation of Habitats and Species Regulations 2010 and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 were consolidated into the Conservation of Habitats and Species Regulations 2017 ('the Habitats Regulations 2017'). Provisions of The Habitats Regulations are described further above. It should be noted that the Habitats Regulations apply within the territorial seas and to marine areas within UK jurisdiction, beyond 12 nm.
The Wildlife and Countryside Act 1981 (as amended)	National	All cetaceans	Schedule five: all cetaceans are fully protected within UK territorial waters. This protects them from killing or injury, sale, destruction of a particular habitat (which they use for protection or shelter) and disturbance. Schedule six: Short-beaked common dolphin *Delphinus delphis*, bottlenose dolphin *Tursiops truncatus* and harbour porpoise; prevents these species being used as a decoy to attract other animals. This schedule also prohibits the use of vehicles to take or drive them, prevents nets, traps or electrical devices from being set in such a way that would injure them and prevents the use of nets or sounds to trap or snare them.
The Countryside and Rights of Way Act (CRoW) 2000	National	All cetaceans	Under the CRoW Act 2000, it is an offence to intentionally or recklessly disturb any wild animal included under Schedule 5 of the Wildlife and Countryside Act.

Legislation	Level of Protection	Species included	Details
Conservation of Seals Act 1970	National	Grey and harbour seal	Provides closed seasons, during which it is an offence to take or kill any seal, except under licence or in certain particular circumstances (grey seal: 1 September to 31 December; harbour seal: 1 June to 31 August). Following the halving of the harbour seal population as a result of the Phocine Distemper Virus (PDV) in 1988, an Order was issued under the Act which provided year round protection of both grey and harbour seal on the east coast of England. The Order was last renewed in 1999.
UK Biodiversity Action Plan (BAP)	National	Harbour porpoise	Harbour porpoise are a feature of the Norfolk, Suffolk and Essex Local Biodiversity Action Plans (LBAPs). These LBAPs are plans which seek to ensure that nationally and locally important species and habitats are conserved and enhanced in a given area through focused local action.

12.2.2 Guidance and Policy

24. The assessment of potential impacts upon marine mammals has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIP).

25. The Overarching NPS for Energy (EN-1) sets out the Government's policy for delivery of major energy infrastructure, with generic considerations which are further considered in the technology-specific NPSs such as the NPS for Renewable Energy Infrastructure (EN-3). Table 12.3 sets out the specific assessment requirements for marine mammals.

26. Paragraphs 2.6.92 to 2.6.99 of EN-3, outline the main priorities and concerns for offshore wind farm development projects that should be considered in relation to marine mammals. EN-3 refers to the preferred methods of construction and noise mitigation practices, as well as the conservation status of marine EPS, and the need to take into account the views of the relevant statutory advisers. Additionally, within EN-3 it is noted that fixed structures (such as offshore wind turbines) are unlikely to pose a significant collision risk to marine mammals.

27. Paragraphs 2.6.97 to 2.6.99 of EN-3 state the specific requirements for marine mammal mitigation; such as monitoring of the area pre- and during piling events, and the use of soft-start procedures before any piling event. This section also highlights the preference for 24 hour working practices to reduce the overall construction program and the resultant impact to marine mammals.

28. In addition to the NPS guidance, there are further planning guidance for strategically planning and consenting marine activities, including:

- The Marine Strategy Framework Directive (MFSD) 2008/56/EC (European Commission, 2008);
- The Marine Policy Statement (MPS) (HM Government, 2011); and
- The East Inshore and East Offshore Marine Plans (HM Government, 2014).

29. Annex I of the MSFD states that to ensure the environmental conditions are considered, the following must be considered:

- Biological diversity should be maintained;
- The quality and occurrence of habitats, as well as the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions;

- All elements of the marine food web, to the extent that they are known, occur at normal abundance and diversity levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity;
- Concentrations of contaminants are at levels not giving rise to pollution effects;
- Properties and quantities of marine litter do not cause harm to the coastal and marine environment; and
- Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

30. The MPS (HM Government, 2011) provides a high-level approach to marine planning and the general principles for decision making. It sets out the framework for environmental, social and economic considerations that need to be taken into account in marine planning. The high level objective of 'Living within environmental limits' covers the points relevant to marine mammals, this requires that:

- Biodiversity is protected, conserved and where appropriate recovered and loss has been halted.
- Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems.
- Our oceans support viable populations of representative, rare, vulnerable, and valued species.

31. Within both the East Inshore and East Offshore Marine Plans (HM Government, 2014), a set of objectives have been set out to ensure biodiversity protections and are of relevance to marine mammals as they cover policies and commitments on the wider ecosystem, as set out within the MPS and the MSFD:

- Objective 6: "*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*"; and
- Objective 7: "*To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas*".

32. Cetaceans (whales, dolphins and porpoises) and pinnipeds (seals) are protected under a wide range of national and international legislation, as outlined in Table 12.2.

Table 12.3 NPS assessment requirements

NPS requirement	NPS reference to text	Section reference
"There are specific considerations from piling noise which apply to offshore wind energy infrastructure proposals with regard to marine mammals, including cetaceans and seals, which have statutory protection. Offshore piling may reach noise levels which are high enough to cause injury, or even death, to marine mammals. If piling associated with an offshore wind farm is likely to lead to the commission of an offence (which would include deliberately disturbing, killing or capturing a European Protected Species), an application may have to be made for a wildlife licence to allow the activity to take place."	Paragraphs 2.6.90-2.6.91 of the NPS EN-3 (July 2011).	Section 12.7.2 provides an overview of the worst case scenario for possible piling works. Section 12.7.4.2 provides an overview of the assessment of pile driving (including noise modelling results).
"Where necessary, assessment of the effects on marine mammals should include details of: Likely feeding areas; Known birthing areas / haul out sites; Nursery grounds; Known migration or commuting routes; Duration of the potentially disturbing activity including cumulative / in-combination effects with other plans or projects; Baseline noise levels; Predicted noise levels in relation to mortality, Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS); Soft-start noise levels according to proposed hammer and pile design; and operational noise."	Paragraph 2.6.92 of the NPS EN-3 (July 2011).	Section 12.6 provides a description of the existing environment. Section 12.7.3 details the assessment of impacts during construction, including pile driving. Section 12.7.5.1 provides the assessment of operational noise.
"The applicant should discuss any proposed piling activities with the relevant body. Where assessment shows that noise from offshore piling may reach noise levels likely to lead to an offence [as described above], the applicant should look at possible alternatives or appropriate mitigation before applying for a licence."	Paragraph 2.6.93 of the NPS EN-3 (July 2011).	Section 12.7.3 details the assessment of impacts during construction, including pile driving, and mitigation measures. Norfolk Vanguard has consulted with NE (Table 12.4).
"The IPC [*now the Planning Inspectorate and the Secretary of State (SoS)*] should be satisfied that the preferred methods of construction, in particular the construction method needed for the proposed foundations and the preferred foundation type, where known at the time of application, are designed so as to reasonably minimise significant disturbance effects on marine mammals. Unless suitable noise mitigation measures can be imposed by requirements to any development consent the IPC [*now SoS*] may refuse the application. The conservation status of marine European Protected Species and seals are of relevance to the IPC [*now SoS*]. IPC [*now SoS*] should take into account the views of the relevant statutory advisors.	Paragraphs 2.6.94 to 2.6.96 of the NPS EN-3 (July 2011).	Chapter 5 Project description describes the need for the foundation options required for Norfolk Vanguard. Section 12.7.2 describes the worst case scenario for marine mammals.

NPS requirement	NPS reference to text	Section reference
Fixed submerged structures such as foundations are likely to pose little collision risk for marine mammals and the IPC [*now SoS*] is not likely to have to refuse to grant consent for a development on the grounds that offshore wind farm foundations pose a collision risk to marine mammals."		
"Monitoring of the surrounding area before and during the piling procedure can be undertaken. During construction, 24-hour working practices may be employed so that the overall construction programme and the potential for impacts to marine mammal communities are reduced in time. Soft start procedures during pile driving may be implemented. This enables marine mammals in the area disturbed by the sound levels to move away from the piling before significant adverse impacts are caused."	Paragraphs 2.6.97 to 2.6.99 of the NPS EN-3 (July 2011).	The outline Project Environmental Management Plan (PEMP) (document 8.14) will be submitted with the DCO application and developed in consultation with Natural England and the Marine Management Organisation and will identify any monitoring requirements.

33. The principal guidance documents used to inform the assessment of potential impacts on marine mammals are as follows:

- The Protection of Marine EPS From Injury and Disturbance: Draft Guidance for the Marine Area in England and Wales and the UK Offshore Marine Area (JNCC *et al*., 2010);
- Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal (Institute for Ecology and Environmental Management (IEEM), 2010);
- Guidelines for Ecological Impact Assessment In the UK and Ireland: Terrestrial, Freshwater and Coastal (Chartered Institute of Ecology and Environmental Management (CIEEM), 2016)
- Environmental Impact Assessment for offshore renewable energy projects – guide (British Standards Institution (BSI), 2015);
- Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments Final Report (Sea Mammal Research Unit Ltd (SMRU Ltd) on behalf of The Crown Estate, 2010);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Cefas, 2012); and
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC, 2010a).

12.2.2.1 EPS guidance

34. The JNCC, Natural England and the Countryside Council for Wales (CCW) (JNCC *et al*., 2010) have produced draft guidance concerning the Regulations on the deliberate disturbance of marine EPS (cetaceans, turtles and Atlantic sturgeon *Acipenser*

oxyrinchus), provides an interpretation of the regulations in greater detail, including for pile driving operations (JNCC, 2010a), seismic surveys (JNCC, 2017a) and the use of explosives (JNCC, 2010b).

35. The draft guidance provides advice on activities at sea that could potentially cause deliberate injury or disturbance to marine mammals and summarises information and sensitivities of the species to which these regulations apply. The guidance refers to the Habitats Directive Article 12 Guidance (EC, 2007) stating the view that, significant disturbance must have some ecological impact.

36. The draft guidance provides the following interpretations of deliberate injury and disturbance offences under both the Habitats Regulations and Offshore Regulations (now the Habitats Regulations 2017), as detailed in the paragraphs below:

> "*Deliberate actions are to be understood as actions by a person who knows, in light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against a species, but intends this offence or, if not, consciously accepts the foreseeable results of his action;*
>
> *Certain activities that produce loud sounds in areas where EPS could be present have the potential to result in an injury offence, unless appropriate mitigation measures are implemented to prevent the exposure of animals to sound levels capable of causing injury*."

37. For the purposes of marine users, the draft guidance states that a disturbance which can cause offence should be interpreted as:

> *"Disturbance which is significant in that it is likely to be detrimental to the animals of an EPS or significantly affect their local abundance or distribution."*

38. The draft guidelines further states that a disturbance offence is more likely where an activity causes persistent noise in an area for long periods of time, and a disturbance offence is more likely to occur when there is a risk of:

- Animals incurring sustained or chronic disruption of behaviour scoring five or more in the Southall *et al*. (2007) behavioural response severity scale; or
- Animals being displaced from the area, with redistribution significantly different from natural variation.

39. The draft guidance (JNCC *et al*., 2010) highlights that sporadic "trivial disturbance" should not be considered as a disturbance offence under Article 12.

40. In order to assess whether a disturbance could be considered non-trivial in relation to the objectives of the Directive, JNCC *et al*. (2010) suggest that consideration should be given to the definition of the FCS of a species given in Article 1(i) of the Habitats Directive. There are three parameters that determine when the conservation status of a species can be taken as favourable:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable element of its natural habitats.
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future.
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

41. Therefore, any action that could increase the risk of a long-term decline of the population, increase the risk of a reduction of the range of the species, and/or increase the risk of a reduction of the size of the habitat of the species can be regarded as a disturbance under the Regulations. For a disturbance to be considered non-trivial, the disturbance to marine EPS would need to be likely to at least increase the risk of a certain negative impact on the species at FCS.

42. JNCC *et al*. (2010) do not provide guidance as to what would constitute a 'significant group' or proportion of the population, but provide some discussion on how to assess whether the numbers potentially affected could be of concern for a population's FCS.

43. JNCC *et al*. (2010) state that:

> "*In any population with a positive rate of growth, or a population remaining stable at what is assumed to be the environmental carrying capacity, a certain number of animals can potentially be removed as a consequence of anthropogenic activities (e.g. through killing, injury or permanent loss of reproductive ability), in addition to natural mortality, without causing the population to decrease in numbers, or preventing recovery, if the population is depleted. Beyond a certain threshold however, there could be a detrimental effect on the population*".

44. Further discussion on the use of thresholds for significance and the permanent or temporary nature of any disturbance is considered by defining the magnitude of potential effect in this assessment (section 12.4.1.3). Consideration of any potential essential habitat or geographical structuring of EPS is provided in the Existing Environment section (section 12.6) of this chapter.

45. In order to assess the number of individuals from a species that could be removed from the regional population through injury or disturbance without compromising the FCS, the ES considers:

- The numbers affected in relation to the best and most recent estimate of population size; and
- The threshold for potential impact on the FCS, which will depend on:
  - The species' / populations' life-history;
  - The species' FCS assessment in UK waters; and
  - Other pressures encountered by the population (cumulative effects).

46. One of the key parameters for consideration within this assessment is the population size. The EPS Guidance advises that the best available abundance estimates could be used as a baseline population size, taking account of any evidence of regional population structuring (JNCC *et al.,* 2010).

47. An EPS licence is required if the risk of injury or disturbance to cetacean species is assessed as likely under The Habitats Regulations.

48. If a licence is required, an application must be submitted, the assessment of which comprises three tests, namely:

- Whether the activity fits one of the purposes specified in Regulation 55(2) – only 55(2)(e) "*preserving public health or public safety or other imperative reasons of overriding public interest, including those of a social or economic nature and beneficial consequences of primary importance for the environment*" is of relevance to marine mammals;
- Whether there are no satisfactory alternatives to the activity proposed (that would not incur the risk of offence); and
- That the licensing of the activity will not result in a negative impact on the species'/ population's FCS.

49. Under the revised definitions of 'deliberate disturbance' in the Habitats Regulations, chronic exposure and / or displacement of animals could be regarded as a disturbance offence. Therefore, if these risks cannot be avoided, then Norfolk Vanguard Limited is likely to be required to apply for an EPS licence from the Marine Management Organisation (MMO) in order to be exempt from the offence.

50. If required, the EPS licence application will be submitted post-consent. At this time, the project design envelope will have been further refined through detailed design and procurement activities and hence further detail will be available on the construction techniques selected for the construction of the wind farm, as well as full consideration of the mitigation measures that will be in place following the

development of the Marine Mammal Mitigation Protocol (MMMP) for piling and UXO clearance.

12.3 Consultation

51. Consultation is a key part of the Development Consent Order (DCO) application process. To date, consultation regarding marine mammals has been conducted through Expert Topic Group meetings, for the Scoping Report (Royal HaskoningDHV, 2016), draft information for the Habitats Regulation Assessment (Royal HaskoningDHV, 2018a) and Preliminary Environmental Information Report (Norfolk Vanguard Limited, 2017). Further consultation took place after the PEIR was made available during Expert Topic Group (ETG) meetings, which took place prior to the project DCO application submission. An overview of the project consultation process is presented within Chapter 7 Technical Consultation.

52. Norfolk Vanguard Limited has followed a non-statutory Evidence Plan Process (EPP), which has included an ETG for marine mammals. The EPP has been used to consult with Natural England, the Marine Management Organisation, The Wildlife Trust (TWT) and Whale and Dolphin Conservation (WDC) to agree the approach taken forward in many aspects of the impact assessment for marine mammals.

53. Pre-application consultation to date has included the following key stages:

- Introduction meeting between Vattenfall Wind Power Limited (VWPL, the parent company of Norfolk Vanguard Limited) and the Marine Management Organisation (14th January 2016);
- Meeting with Natural England and the Marine Management Organisation to discuss aerial survey scope (21st March 2016);
- EIA Scoping Report (Royal HaskoningDHV, 2016);
- The Scoping Opinion (the Planning Inspectorate, 2016);
- EIA Marine Mammal Method Statement (Royal HaskoningDHV, 2017a);
- Habitats Regulation Assessment (HRA) Marine Mammal Method Statement (Royal HaskoningDHV, 2017b);
- HRA Offshore Screening (Royal HaskoningDHV, 2017c);
- Natural England's Current Advice on Assessment of Impacts on the Southern North Sea Harbour Porpoise candidate Special Area of Conservation (cSAC) (13th June 2017);
- EPP marine mammal ETG meetings (15th February 2017 and 6th July 2017);
- EPP marine mammal ETG conference calls (26th March 2018 and 8th December 2017);
- Preliminary Environmental Information Report (Norfolk Vanguard Limited, 2017); and

- Draft Information for Habitats Regulation Assessment (Royal HaskoningDHV, 2018a).

54. Detailed minutes of the Evidence Plan Process meetings are provided in Appendices 9.24 and 25.9 of the Consultation Report (document reference 5.1) with the DCO application.

55. It is acknowledged that new information and guidance may become available. However, it has been necessary to have a cut-off period for the DCO application submission, after which, any further developments will be considered during the examination phase. It was agreed with the marine mammal ETG at the EPP meeting on 15th February 2017 that a reasonable cut-off point was the date of receipt of comments upon the PEIR in December 2017.

56. Relevant consultation responses, to date, from the Scoping Opinion, PEIR and the EPP Marine Mammals Meetings are presented in Table 12.4.

Table 12.4 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the ES
Stiffkey Parish Council	November 2016 (Scoping Opinion)	To be included in the ES: Identification of the area over which biological effects may occur to inform baseline data collection and determining the connectivity between key wildlife (and specifically marine) populations and proposed wind energy sites. The methodology proposed to monitor impacts into a wildlife (and specifically marine) population level context and the actions to be taken to determine whether they are biologically significant. How responses will be measured during wind farm construction and operation to determine disturbance effects and avoidance responses. What efforts will be made (including learning from other industries and similar projects) to inform risk assessments and the effectiveness of mitigation measures, particularly given this will be a further offshore wind development along the same stretch of coast where there is now likely to be a growing need to consider the population level consequences and cumulative impacts of these activities on wildlife/marine species.	The range of potential impacts and connectivity with marine mammals has been considered in defining the study area for marine mammals (see section 12.5.1). A Marine Mammal Mitigation Plan (MMMP) (document reference 8.13) would be developed in consultation with key stakeholders. This will include monitoring where appropriate. A draft MMMP for piling (document reference 8.13) is submitted with the DCO application. Information from a wide range of sources, information and lessons learned on a variety of different project and offshore developments both in the UK and overseas has been used to inform the risk assessment and effectiveness of proposed mitigation measures. This will continue to develop as the project progresses, for example the development of the MMMP will be based on the latest information and guidance when it is finalised prior to construction (see section 12.7.1).
The Planning Inspectorate	November 2016 (Scoping Opinion)	It is noted that piling would be required to construct the turbines. The piling method should be clearly described within the ES and the associated impacts assessed as part of the EIA.	Piling activities are described in Chapter 5 Project Description. The worst-case scenario in relation to marine mammals is outlined in section 12.7.2 and the impacts are assessed in sections 12.7.3 to 12.7.6.
The Planning Inspectorate	November 2016 (Scoping Opinion)	Where existing survey data (e.g. East Anglia FOUR) is relied upon, their suitability for Norfolk Vanguard OWF should be agreed with relevant consultees; in particular the spatial and temporal scope of the surveys should be considered.	The scope of Norfolk Vanguard marine mammal surveys was discussed and agreed with Natural England and the Marine Management Organisation at a meeting in March 2016. The approach to site characterisation was further outlined in the Marine Mammal Method Statement (February 2017), and

Consultee	Date / Document	Comment	Response / where addressed in the ES
			discussed and agreed during the February 2017 Expert Topic Group Meeting
The Planning Inspectorate/ Marine Management Organisation /TWT	November 2016 (Scoping Opinion)	The underwater noise assessment methodology should be agreed with the relevant statutory consultees where appropriate and clearly outlined within the ES. The Applicant's attention is drawn to the recently published guidelines by the National Oceanic and Atmospheric Administration (NOAA). The baseline environment should be established and potential noise and vibration impacts should be assessed against the baseline. The methods and modelling software should be detailed within the ES; along with the project specific detail that it utilises.	The approach to underwater noise modelling was outlined in the Marine Mammal Method Statement (February 2017), and discussed and agreed during the February 2017 Expert Topic Group Meeting. Thresholds outlined in the NOAA guidance have been used in the modelling. Environmental conditions at the site, including bathymetry, sediment type, temperature, salinity and tidal state were taken into account in the underwater noise modelling (see Appendix 5.3). The underwater noise modelling methodology is detailed in Appendix 5.3.
The Planning Inspectorate	November 2016 (Scoping Opinion)	The Applicant's attention is drawn to paragraph 2.6.92 of NPS EN-3 and the need to provide details of likely feeding areas; known birthing areas/haul out sites; nursery grounds; and known migration or commuting routes.	The requirements of NPS EN-3 are outlined in section Table 12.3. Breeding/ haul out sites and telemetry studies are discussed for Pinnipeds in section 12.6.2.
The Planning Inspectorate	November 2016 (Scoping Opinion)	Where modelling is undertaken to determine the abundance of cetaceans, the ES should explain the methodology used.	Appendix 12.1 outlines the data analysis completed to determine site specific harbour porpoise density estimates.
The Planning Inspectorate	November 2016 (Scoping Opinion)	The Applicant's attention is drawn to the existence of the Defra Marine Noise Registry which could inform the baseline noise environment.	Baseline ambient noise is discussed in section 3 of Appendix 5.3
The Planning Inspectorate/ NE	November 2016 (Scoping Opinion)	Consideration should be given to disturbance at seal haul outs from vessel transit to and from operational ports.	Any potential disturbance at seal haul-outs sites are assessed in section 12.7.4.7 for construction and section 12.7.5.5 for O&M.
The Planning Inspectorate/ Norfolk County Council	November 2016 (Scoping Opinion)	The Scoping Report notes that there are no designated sites for grey seals in South-east England. Breeding grey seals on Norfolk Coast are a relatively recent phenomenon (first modern records from around 2001) but numbers have	In the PEIR and EIA all current seal haul-out sites at the closest point to the OWF site, cable route, landfall and vessel routes have been taken into account and any potential disturbance at seal haul-

Consultee	Date / Document	Comment	Response / where addressed in the ES
		increased rapidly (2,342 pups born at Blakeney Point in 2015-16 and 1,116 at Horsey). These rookeries post-date the Natura2000 citations and, as such, grey seals were not included as designated features of the North Norfolk SAC or Horsey-Winterton SAC. Nevertheless recent advice from Natural England is that if designated today, or if the citations are updated, the grey seal would certainly feature as a Conservation Objective of these sites. The County Council would suggest that they should be considered alongside the other Conservation Objectives.	outs sites are assessed in section 12.7.4.7 for construction and section 12.7.5.5 for O&M. In the Report to inform the HRA (document reference 5.3) all relevant designated sites and their Conservation Objectives will be considered. While grey seal are not currently a qualifying feature at the North Norfolk SAC (which includes Blakeney Point) or Horsey-Winterton SAC, it is recognised that these sites are important for the population, as breeding, moulting and haul-out sites. Therefore, in the report to inform the HRA consideration will be given to grey seal as part of the North Norfolk SAC or Horsey-Winterton SAC, to determine if there is the potential for any disturbance at these sites.
The Planning Inspectorate/ NE	November 2016 (Scoping Opinion)	The Secretary of State does not agree impacts to marine mammals for changes to water quality during construction and decommissioning can be scoped out of the EIA, however does agree it can be scoped out for the operational phase.	Any changes to water quality and the potential impacts to marine mammals are assessed in section 12.7.4.9 for construction and section 12.7.6.7 for decommissioning.
The Planning Inspectorate	November 2016 (Scoping Opinion)	The assessment should consider the displacement and potential barrier effects as a result of noise emitted during the construction period and therefore expects this to be covered within the assessment of 'underwater noise' impacts.	Any displacement and potential barrier effects as a result of noise emitted during the construction period are assessed in section 12.7.4.5.
The Planning Inspectorate	November 2016 (Scoping Opinion)	The ES should set out in full the potential risk to European Protected Species (EPS) and confirm if any EPS licences will be required. Applicants are encouraged to consult with Natural England (NE) and, where required, to agree appropriate requirements to secure necessary mitigation. It would assist the examination if applicants could provide, with the application documents, confirmation from NE whether any issues have	The requirements for an EPS licence application to the Marine Management Organisation, in consultation with NE, will be determined post-consent. At post-consent, the project design envelope will have been further refined through detailed design and procurement activities and hence further detail will be available on the techniques selected for the construction of the

Consultee	Date / Document	Comment	Response / where addressed in the ES
		been identified which would prevent the EPS licence being granted.	wind farm, as well as full consideration of the mitigation measures that will be in place following the development of the MMMP. A draft MMMP for piling (document reference 8.13) is submitted with the DCO application. It is noted that for the examination, the applicant will provide information regarding any issues associated with EPS which have been identified in consultation with NE, as appropriate.
NE	November 2016 (Scoping Opinion)	It is not clear from the Scoping Report whether the site specific surveys referred to are ornithology surveys where marine mammal data have been collected or if they are marine mammal only surveys.	Combined aerial surveys were designed and undertaken for both ornithology and marine mammals. Further information on the surveys is provided in section 12.5.2 and Appendix 12.1.
NE	November 2016 (Scoping Opinion)	If the timeline allows, SCANS III survey data should be incorporated.	Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III (Small Cetaceans in European Atlantic waters and the North Sea) aerial and shipboard surveys (Hammond *et al*., 2017) has been included in characterisation of the existing environment (section 12.6) and density estimates from the SCANS-III surveys as well as sites specific density estimates for harbour porpoise have been used in the impact assessment (see Table 12.21).
NE	November 2016 (Scoping Opinion)	NE advises that the impact assessment should take account of the Southern North Sea pSAC (now cSAC) for harbour porpoise, not just the North Sea Management Unit. The information provided by the applicant in relation to potential effects on the pSAC (now cSAC) from construction noise will form the basis for the Habitats Regulations Assessment (HRA). We also advise that the approach to assessing impacts on the Southern North Sea pSAC (now cSAC) should be discussed and agreed with the relevant statutory bodies	The impact assessment considers impacts on the Southern North Sea cSAC, however, during the topic group meetings in February and July 2017, NE advised that the North Sea Management Unit should be the key focus when determining population level impacts on harbour porpoise from the cSAC.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		during the Evidence Plan process to ensure the most appropriate and up to date methods and information are incorporated.	
NE	November 2016 (Scoping Opinion)	Figures 2.14 and 2.15 appear to show grey and harbour seal mean at sea usage estimates to be 0 – 1.0 individuals per km^2 at the array and 0 – 5 individuals per km^2 in the provisional offshore cable corridor for both species, not 0 – 0.2 individuals per km^2 as stated here.	Units from these figures have now been included which shows the numbers represent individuals per $25km^2$ (5 x 5km cells)
NE	November 2016 (Scoping Opinion)	NE advise that the assessment of vessel interaction should also take account of the increase in the number of vessel movements in the area and the associated increase in underwater noise, as well as increased likelihood of collision.	Any potential vessel interaction (collision risk) is assessed in section 12.7.4.6 for construction and section 12.7.5.4 for O&M. Any potential disturbance from vessel noise is assessed in section 12.7.4.4 for construction and section 12.7.5.3 for O&M.
TWT	November 2016 (Scoping Opinion)	It would be useful to have further information on how absolute densities can be determined from the aerial digital surveys. It is important that disturbance impacts are considered in line with the conservation objectives for the Southern North Sea pSAC (now cSAC). Possible mitigation measures should be considered with regards to reducing disturbance impacts.	Appendix 12.2 outlines the approach to analysing density estimates and details correction factors for determining absolute density estimates. Disturbance impacts on harbour porpoise, including the Southern North Sea cSAC are assessed in section12.7.4.2.4. Mitigation measures in the MMMP (document reference 8.13) will be aimed at reducing any risk of physical or auditory injury in marine mammals and may include measures which actively disturb animals, such as soft-start and use of ADDs, in order to protect them. However, in addition to the MMMP it is proposed to have a separate approach to reduce significant disturbance of harbour porpoise in the cSAC, this will follow a similar approach to the 'SNS cSAC Site Integrity Plan' submitted at the East Anglia THREE examination.

Consultee	Date / Document	Comment	Response / where addressed in the ES
WDC	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	Pleased to see floating foundations as an option if these avoid the use of piling.	Chapter 5 Project Description describes the foundation options, including floating turbines with tension mooring lines. These could have up to four piled anchors per foundation. Potential entanglement has been assessed in section 12.7.5.6. Any potential impacts from piling the anchor foundations have been assessed for pin-piles in section 12.7.4.2.
TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	Suggest using The Marine Life Surveys, Sea Watch surveys and Friends of Horsey seal data as additional data sources.	Information from the Marine Life Surveys and Sea Watch surveys websites has been included in the baseline information in section 12.6. Data from the Friends of Horsey seals has also been included (section 12.6.2).
TWT, WDC	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The HRA should consider cSAC numbers.	As agreed at the EPP meeting in February 2017, the NS MU, cSAC area (winter and summer) and potential number of harbour porpoise in the cSAC will be assessed in the Report to inform the HRA (document reference 5.3).
NE	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	UXO clearance activities should also be incorporated in the assessment.	Potential impacts from UXO clearance activities have been assessed in section 12.7.4.1
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The key marine mammal species to be assessed within the ES, as detailed in the method statement, are agreed.	The key marine mammal species, harbour porpoise, grey seal and harbour seal, as agreed at the EPP meeting in February 2017 have been assessed in section 12.6.4.
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	Agreed that the survey data in NV West is to be completed for 2 years and that the 32 months of data for NV East/East Anglia FOUR is appropriate.	Section 12.5.2 outlines the survey data, as agreed at the EPP meeting in February 2017.
NE, WDC	15th February 2017 -	The additional data sources as detailed in the method	Section 12.5.2 outlines the data sources, as agreed

Consultee	Date / Document	Comment	Response / where addressed in the ES
	Evidence Plan Process for Marine Mammals Meeting	statement are agreed.	at the EPP meeting in February 2017.
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The density estimates to use in the assessment as detailed in the method statement are agreed.	Section 12.6.3 outlines the density estimates used in the assessment.
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The reference populations as detailed in the method statement are agreed.	Section 12.6.3 outlines the reference populations used in the assessment.
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The impact assessment methodology as detailed in the method statement is agreed.	Section 12.6.3 outlines the impact assessment methodology used in the assessment.
WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	Impacts to be assessed as detailed in the method statement are agreed.	Section 12.6.4 assesses the potential impacts, as agreed at the EPP meeting in February 2017.
NE, WDC, TWT, The Centre for Environment, Fisheries and Aquaculture Science (Cefas)	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The approach to underwater noise modelling as detailed in the method statement is agreed.	Section 12.7.4.2 and Appendix 5.1 provide details on the approach to the underwater noise modelling used in the assessment.
NE, WDC, TWT, Cefas	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The underwater noise thresholds for marine mammals as reported by NMFS (NOAA, 2016), Southall *et al*. (2007) and Lucke *et al*. (2009) should be used in the modelling and presented in the ES.	Section 12.7.4.2 and Appendix 5.3 provide details on the approach to the underwater noise thresholds for marine mammals used in the assessment.
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The tiered approach to CIA screening as detailed in the method statement is agreed upon.	Section 12.4.2 outlines the tiered approach used in the CIA screening.

Consultee	Date / Document	Comment	Response / where addressed in the ES
NE, WDC, TWT	15th February 2017 - Evidence Plan Process for Marine Mammals Meeting	The cut off for the final CIA screening as detailed in the method statement is agreed.	As outlined in section 12.2, it was agreed with the marine mammal topic group at the Evidence Plan meeting in February 2017 that the cut-off point is the date of receipt of comments upon the PEIR, in December 2017.
NE, WDC, TWT, Cefas	6th July 2017 - Evidence Plan Process for Marine Mammals Meeting	A summary of the draft underwater noise modelling results was presented to the group.	The underwater noise modelling is discussed in section 12.7.4.2 and Appendix 5.3.
NE, WDC, TWT, Cefas	6th July 2017 - Evidence Plan Process for Marine Mammals Meeting	The approach to the HRA was discussed and agreed.	A report to inform the HRA (document reference 5.3) will be provided with the DCO application for Norfolk Vanguard and will be consulted upon with the marine mammal topic group in advance.
NE	6th July 2017 - Evidence Plan Process for Marine Mammals Meeting	26km harbour porpoise disturbance range should be applied to the EIA.	Harbour porpoise disturbance, using an impact range of 26km is assessed in section 12.7.4.2.4.
NE, TWT	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	The marine mammal PEIR chapter is quite complicated and difficult to follow.	This has been reviewed, edited and simplified, where possible, with additional scenarios and assessments now included in the Appendix 12.4, 12.5 and 12.6.
NE	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	Reference to the cSAC 'population' should be removed from the assessments. This is not a distinct population and its use would be misleading.	Reference to cSAC 'population' has been removed from ES chapter and report to inform the HRA, with an additional assessment included in Appendix 12.4, for information, based on the estimate that the SNS cSAC could support 29,384 harbour porpoise (SCANS-III data for 17.5% of the UK North Sea MU). A separate appendix will also be included with the report to inform the HRA (document reference 5.3). *TWT response on the 18th Dec by email confirms this can be included as an appendix to the HRA.*

Consultee	Date / Document	Comment	Response / where addressed in the ES
NE, TWT, Cefas	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	Underwater noise note on different underwater noise models, source level, length of pile in contact with water and pile diameter proxies, was issued with minutes.	See responses below.
NE, TWT, Cefas	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	Use NOAA thresholds for modelling PTS and TTS. Other PTS/TTS thresholds can be removed from the ES.	As agreed, the NOAA (NMFS, 2016) thresholds and criteria have been used in the assessment for PTS and TTS in the ES chapter. The PTS/TTS thresholds from Southall *et al*. (2007) and Lucke *et al*. (2009) have been included in the additional assessments in Appendix 12.5.
NE, TWT, Cefas	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	Use 26km for disturbance however present Lucke *et al* 2009 thresholds in the ES for context as it is acknowledged that not all parties agree with the 26km disturbance range. Present a range of 50, 75 and 100% possible avoidance response.	As agreed, in the ES disturbance has been assessed based on 26km radius and behavioural response has been assessed based on Lucke *et al*. (2009). As agreed, a range (50%, 75% and 100%) in relation to the proportion of the population impacted has been included in Section 12.7.4.2.5 Table 12.48 for possible avoidance.
NE, TWT, Cefas	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	Check report by Heinänen and Skov (2015) which indicates a negative relationship between the number of ships and the distribution of harbour porpoises.	Reference to the threshold level of impact related to number of vessels (approximately 20,000 ships per year) in Heinänen and Skov (2015) has been used in the assessment in section 12.7.4.4.
NE, TWT, Cefas	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	The CIA in the PEIR is confusing with so many scenarios. - All agreed to put the discussion of scenarios in an appendix and leave only one assessment scenario in the CIA. Agreed that the 'likely scenario' presented in the PEIR is appropriate to take forward in the ES.	As agreed the most 'likely scenario' for the potential worst-case for the CIA has been assessed in the ES chapter. The theoretical worst-case and other scenarios have been assessed in Appendix 12.6.
NE, TWT, Cefas	8th December 2017 - Evidence Plan Process for Marine Mammals conference call	Agreed the assumptions of four UXO operations and four seismic operations in the North Sea at any one time is conservative and appropriate to use in the assessment for the ES and HRA.	As agreed the assessment has been based on the potential worst-case of a possible four UXO operations and four seismic operations in the North Sea at any one time.
NE, MMO, TWT, WDC	26th March 2018 -	The HRA comments and feedback were discussed.	These have been addressed in the report to inform

Consultee	Date / Document	Comment	Response / where addressed in the ES
	Evidence Plan Process for Marine Mammals conference call		the HRA (document reference 5.3) and comment log.
NE	11/12/17 PEIR Response	Further justification and confirmation regarding the use of certain data sets and evidence is required, in addition to a detailed impact assessment of Unexploded Ordnance (UXO) detonation.	Underwater noise modelling for UXO clearance at Norfolk Vanguard has been conducted and included in the ES – Section 12.7.4.1.
NE	11/12/17 PEIR Response	Natural England are particularly keen to have further discussions regarding the strategic approach proposed to mitigate the impacts to the Southern North Sea harbour porpoise cSAC. Natural England advise that a range of scenarios should be used to provide a greater level of confidence when assessing (a) the underwater noise impacts and proportion of population impacted and (b) the density estimates of the MU ref population.	Acknowledged and further discussions regarding the strategic approach proposed to mitigate the impacts to the Southern North Sea harbour porpoise cSAC with the SNCBs and MMO are ongoing. The assessments have included, where applicable a range of scenarios, which have (a) included the potential proportion of North Sea MU population that could be impacted; and (b) the density estimates for the Norfolk Vanguard site and latest SCANS-III density estimate. The density estimates of the MU ref population are over a wide scale and were deemed not appropriate to use, but assessments have been based on the North Sea MU abundance estimate.
NE	11/12/17 PEIR Response	Discussions will be ongoing regarding some outstanding concerns including (but not limited to): • the use of a spatial or population based assessment within the HRA; • the use of a 5% threshold at HRA, and • whether the use of SCANS III population is appropriate to use.	Addressed in the report to inform the HRA (document reference 5.3).
NE	11/12/17 PEIR Response - Summary of comments	Data use: The Management Unit population is the appropriate population for percentage impacts to the population to be assessed against throughout the assessment. Following further discussion on the	The North Sea MU population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al.*, 2017) based on the SCANS-III data, has been used as the reference population throughout the

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		teleconference call on the 8th December 2017 we will provide further confirmation as to whether the SCANS III population is appropriate to in our technical advice note that we will be providing by 5th January 2018. It should also be noted that the site selection document for the Southern North Sea cSAC states it is estimated the site supports approximately 18,500 individuals and this number should not be referred to as an estimated population. Natural England also wish to highlight that the Lincolnshire Wildlife Trust conduct grey seal counts at Donna Nook annually and this data is widely available.	assessment. NE confirmed (letter date 03/01/18; Point 2) that it is appropriate to use the SCANS-III population data (Hammond *et al*., 2017) as the same area is used as the Management Unit. It is acknowledged that, as outlined in Section 12.6.1.4, it is not appropriate to use SNS cSAC site population estimate in any assessments of effects of plans or projects, as these need to take into consideration population estimates at the MU level (JNCC, 2017b). However, as requested by TWT and WDC, an additional assessment has been included in Appendix 12.4, for information, based on the estimate that the SNS cSAC could support 29,384 harbour porpoise (SCANS-III data for 17.5% of the UK North Sea MU). The data from the most recent seal counts has been updated.
NE	11/12/17 PEIR Response - Summary of comments	UXO assessment: Further consideration is required regarding the UXO assessment, including the following: • Consideration of a larger number/size of bombs; • The use of more appropriate examples of UXO assessments rather the Beatrice Offshore Wind Farm (BOWL) i.e. East Anglia ONE; • Noise modelling should be undertaken and the NMFS (2016) unweighted Peak SEL metric be used to ascertain the potential zone of PTS; • Consideration of the UXO works within the RIAA, and • The design of a Marine Mammal Mitigation Protocol (MMMP) for UXO as well as the MMMP for piling.	Underwater noise modelling for UXO clearance at Norfolk Vanguard has been conducted and included in the ES – Section 12.7.4.1. This includes the NMFS (2016) unweighted Peak SEL metric to assess the potential PTS range and impact area. The assessment of the potential UXO at Norfolk Vanguard has included a strategic UXO risk management assessment as outlined in section 12.7.4.1 and presented in Appendix 5.2. UXO clearance disturbance effects have been assessed in the report to inform the HRA (document reference 5.3). As outlined in section 12.7.4.1.6 and 12.12.1.2, a UXO clearance MMMP will be produced post-consent in consultation with Natural England and

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			will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Vanguard offshore project area, and detailed project design. The MMMP for UXO clearance will detail the proposed mitigation measures to reduce the risk of any lethal injury and permanent auditory injury to marine mammals during any underwater detonations.
NE	11/12/17 PEIR Response - Summary of comments	Strategic Approach: Natural England welcomes the opportunity for further discussion with Vattenfall regarding a Site Integrity Plan and a possible strategic approach to mitigation as part of the Evidence Plan Process.	Acknowledged and further discussions regarding the Site Integrity Plan and a possible strategic approach to mitigation with the SNCBs and MMO are ongoing. The draft SIP has been issued to ETG and submitted with the DCO application (document 8.17),
NE	11/12/17 PEIR Response - Summary of comments	Permanent Threshold Shift in seals: It is reported in para 425 that the SEL_{cum} for PTS in seals is 21km, which would in turn imply that the mitigation zone would also need to be 21km. We query whether this is correct given the low frequency of seals and the fact that it's far greater than the other PTS results for harbour porpoise.	As agreed, assessments in the ES are based on NMFS (2016) thresholds for PTS and TTS and Lucke *et al*. (2009) threshold for possible avoidance (with the additional assessments based on Southall *et al*. (2007) included in Appendix 12.5).
NE	11/12/17 PEIR Response - Summary of comments	Disturbance range of 26km for seals (para 462): Whilst Natural England are content for the proposals of a 26km disturbance range to be used for seals as well as harbour porpoise Natural England wish to highlight that further justification and clarification as to why this is being used would be helpful and advise that it is made clear within the application that this is not necessarily Natural England's advice.	Further justification based on Russell *et al*. (2016) has been included in section 12.7.4.2.4. It is acknowledged that this is not Natural England's current advice but that its use is accepted.
NE	11/12/17 PEIR Response - Summary of comments	Density estimates of the MU ref population: (para 725): We advise that a range of density estimates should be presented. This will provide a greater level of confidence in the assessment acknowledging that the SCANS data provides just a snapshot in time and highlighting that the winter	A range of density and abundance estimates have been reviewed in Section 12.6.1.1.3 for harbour porpoise. Potential impacts have been based on the highest site specific survey density estimates and the

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		population of the cSAC could therefore be far higher than assessed.	SCANS-III survey density estimate, throughout the assessment.
NE	11/12/17 PEIR Response - Summary of comments	Underwater noise impacts: Following the call on the 8th Dec 2017 we wish to reiterate that it would be most appropriate to present a range in relation to the proportion of the population impacted: for example at 50%, 75% and 100%.	As agreed, a range (50%, 75% and 100%) in relation to the proportion of the population impacted has been included in Section 12.7.4.2.5 Table 12.50 for possible avoidance.
NE	11/12/17 PEIR Response - Summary of comments	HRA - Threshold of 5%: Following the call on the 8th Dec 2017 Natural England are having further internal discussions regarding this issue and will provide a further technical advice note by the 5th January 2018.	Addressed in the report to inform the HRA (document reference 5.3).
NE	11/12/17 PEIR Response - Summary of comments	HRA - spatial vs population level assessment: Following the call on the 8th Dec 2017 Natural England are having further internal discussions regarding this issue and will provide a further technical advice note by the 5th January 2018 and will confirm that we are content with the summer and winter areas proposed for assessment.	Addressed in the report to inform the HRA (document reference 5.3).
NE	11/12/17 PEIR Response – Point 1: 12.6.1.1.3, para 131	This paragraph states the Management Unit (MU) is the appropriate scale, at which effects of projects and plans should be assessed, yet they are not included in the rest of the assessment as a reference population for HP and there is no explanation as to why the SCANS III NS AU has been chosen instead? Natural England considers the MU population to be the appropriate population for percentage impacts to the population to be assessed against throughout the assessment.	The SCANS-III survey area for the North Sea, the combined area of the aerial survey blocks used is very similar (within a few percent) to the area of the AU, which is the same as North Sea MU. As outlined below, NE confirmed (letter date 03/01/18; Point 2) that it is appropriate to use the SCANS-III population data as the same area is used as the Management Unit. The North Sea MU population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al.*, 2017) based on the SCANS-III data, has been used as the reference population throughout the assessment.
NE	11/12/17 PEIR Response – Point 2: 12.6.1.4, para 206	Please can the text be changed here to reflect that the site selection document for the Southern North Sea cSAC states it is estimated the site supports approximately 18,500	Text has been amended to: The SNS cSAC Site Selection Report (JNCC, 2017b) identifies that the SNS cSAC site supports approximately 18,500

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		individuals and this number should not be referred to as an estimated population. Natural England therefore considers it not appropriate for percentage impacts to the cSAC 'population' to be presented throughout the assessment as this is very misleading.	individuals (95% CI = 11,864 - 28,889) for at least part of the year (JNCC, 2017b). However, JNCC (2017b) states that because this estimate is from a one-month survey in a single year (the SCANS-II survey in July 2005) it cannot be considered as an estimated population for the site.
NE	11/12/17 PEIR Response – Point 3: 12.6.2.1.2, para 226	Natural England welcomes that consideration will be given to grey seal as part of the North Norfolk Coast SAC or Horsey-Winterton SAC in the HRA, to determine if there is the potential for any disturbance, despite them not being a designated feature of either site. However, it is noted that this then conflicts with Appendix 10.4. - is it therefore assumed that the seals around Norfolk are part of the designated population of the Humber SAC?	For the assessment in the report to inform the HRA (document reference 5.3), the south-east management unit has been used as the reference population, as well as latest counts for the Humber Estuary SAC. Text has been clarified in section 12.6.4 on the MUs and site counts used in the assessments for the ES and Report to Inform the HRA (document reference 5.3).
NE	11/12/17 PEIR Response – Point 4: 12.6.2.3.1, para 288	Natural England queries the statement that there are no recent counts for the number of grey seal in the Humber Estuary SAC. Lincolnshire Wildlife Trust conduct counts at Donna Nook annually and this data is widely available. The meaning of this statement should be clarified if these counts are not what was intended.	Text has been corrected and updated.
NE	11/12/17 PEIR Response – Point 5: 12.7.1.1, para 305	Natural England welcomes the commitment from Vattenfall to further discussions with Natural England on the appropriate mitigation zone and methods for achieving full mitigation of that zone.	Acknowledged.
NE	11/12/17 PEIR Response – Point 6: 12.7.3.1 –UXO assessment	Natural England considers the UXO assessment undertaken in section 12.7.3.1 to be confusing. It is not clear why the assessment from Beatrice Offshore Wind Farm (BOWL) has been used as a substitute for an assessment at Vanguard. Natural England consider it highly likely, based on the recent experience of other offshore wind farms in the southern North Sea, that a larger number of larger bombs are likely to be present in the vicinity of Vanguard than BOWL. Natural	Underwater noise modelling for UXO clearance at Norfolk Vanguard has been conducted and included in the ES – Section 12.7.4.1. This replaces the assessment based on the Beatrice Offshore Wind Farm. As outlined above, the modelling includes the NMFS (2016) unweighted Peak SEL metric to assess the potential PTS range and impact area.

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		England considers there are more appropriate examples of UXO assessments that are more relevant to Vanguard that could be used instead. In paragraph 332 it states that BOWL assessed the potential for physical injury based on the peak sound pressure (SPL) threshold of 240 dB for all marine mammals from Yelverton et al., 1973. Natural England's current advice regarding assessment of potential impacts from UXO detonations is that noise modelling should be undertaken and the NMFS (2016) unweighted Peak SEL metric be used to ascertain the potential zone of PTS as these criteria represent the current best available evidence on noise metrics. Again the detonation of UXO is likely to have a significant effect on the interest features of the Southern North Sea cSAC and therefore should be included in the RIAA.	The assessment of the potential UXO at Norfolk Vanguard has included a strategic UXO risk management assessment (presented in Appendix 5.2 and outlined in section 12.7.4.1. UXO clearance effects will be assessed in the Report to inform the HRA (document reference 5.3).
NE	11/12/17 PEIR Response – Point 7: 12.7.3.2 – Underwater noise during piling	Natural England queries the use of metrics from Parvin *et al*., (2007) as described in paragraph 380. This work considers impacts to both fish and marine mammals using the same metrics and Natural England do not consider them to be the most appropriate to be used in a marine mammal assessment. It is not clear what value they add to the assessment when the NMFS (2016), Southall et al., (2007) and Lucke *et al*., (2009) are all being considered in the assessment. Following the call on the 8th Dec 2017 we acknowledge Vattenfall's commitment to removing reference to this paper for the application.	As agreed the assessment based on the metrics from Parvin *et al*. (2007) has not been included in the ES or Appendix 12.5 with additional assessments. As agreed, assessments in the ES are based on NMFS (2016) thresholds for PTS and TTS and Lucke *et al*. (2009) threshold for possible avoidance (with the additional assessments based on Southall *et al*. (2007) included in Appendix 12.5).
NE	11/12/17 PEIR Response – Point 8: Para 365	Natural England welcomes the proposed extended ramp-up period to allow animals to move further away.	Acknowledged.
NE	11/12/17 PEIR Response – Point 9: Para 366	In addition to the text presented under Figure 4.2 in Appendix 5.1, Natural England would welcome further explanation of the use of data from 7m diameter piles as a	As outlined in the underwater noise note (8th December 2017), the pile diameter is used for estimating the frequency content of the noise;

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		proxy for 8.5m or 15m diameter piles in the noise modelling.	large monopiles produce more low frequency content and the smaller pin piles contain more high frequency content, due to the dimensions and acoustics of the pile. For offshore piling modelling, frequency data has been sourced from Subacoustech's noise measurement database and an average taken to obtain representative third octave (i.e. frequency) levels for installing monopiles and pin piles. The frequency spectrum for a pile of 7.0m in diameter is suitable for the monopile modelling and piles of approximately 4.0m in diameter have been used for pin pile modelling.
NE	11/12/17 PEIR Response – Point 10: Para 371	Natural England queries the approach of incorporating the length of pile in contact with the water in to the model as this would change over the course of a monopile foundation being installed. Further explanation of this point would be welcomed.	As outlined in the underwater noise note (8th December 2017), the radiating pile length in the water would not change, provided that the hammer remains above the surface of the water. Investigations with limited data for subsea piling have shown that the difference to the situation where the hammer is above the water is small. It is thought that, while the radiating area would progressively reduce for subsea hammer piling, the introduction of the hammer itself would contribute to the noise, perhaps offsetting the effect.
NE	11/12/17 PEIR Response – Point 11: Table 12.47 – and all subsequent tables	Natural England considers that all reference to percentage of the SNS cSAC population impacted should be removed. As previously mentioned, there is no population estimate for the SNS cSAC and presenting results in this way is misleading.	Reference to cSAC 'population' has been removed from ES chapter, with an additional assessment included in Appendix 12.4, for information, based on the estimate that the SNS cSAC could support 29,384 harbour porpoise (SCANS-III data for 17.5% of the UK North Sea MU).
NE	11/12/17 PEIR Response – Point 12: Para 479	Again, reference to the SNS cSAC population should not be included here as there is no population estimate for the SNS cSAC. Rather, the spatial impact of concurrent piling	It is acknowledged that, as outlined in Section 12.6.1.4, it is not appropriate to use SNS cSAC site population estimate in any assessments of effects

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		scenarios should be considered in line with the SNCB threshold approach.	of plans or projects, as these need to take into consideration population estimates at the MU level (JNCC, 2017b). However, as requested by TWT and WDC, an additional assessment has been included in Appendix 12.4, for information, based on the estimate that the SNS cSAC could support 29,384 harbour porpoise (SCANS-III data for 17.5% of the UK North Sea MU). In the ES, the spatial impact has been put into the context of the North Sea MU harbour porpoise population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al*., 2017) based on the SCANS-III data, which has been used as the reference population throughout the assessment. in the Report to inform the HRA (document reference 5.3), the spatial impact has been assessed in relation to the area of the SNS cSAC, following the current statutory nature conservation body (SNCB) threshold approach.
NE	11/12/17 PEIR Response – Point 13: Para 554	Natural England queries if the additional vessel movements could be represented as a percentage increase from baseline to allow a better understanding the level of increase.	Vessel movements as a percentage increase from baseline has been included in the assessment (section 12.7.4.4).
NE	11/12/17 PEIR Response – Point 14: Para 563 & 710	Natural England queries where an avoidance rate of 95% has come from? As agreed on the call on the 8th Dec 2017, Vattenfall have agreed to include further justification for the use of this avoidance rate.	Further information and justification for the avoidance rate has been included in section 12.7.4.6.
NE	11/12/17 PEIR Response – Point 15: Para 605	Natural England notes that the majority of operational turbine noise measurements were taken during Round 1 and therefore do not capture the subsequent increases in turbine size and developments or changes in the design and engineering of turbines. We would welcome further work to be undertaken to monitoring the operational noise of larger turbines to update the evidence in this area and our	Acknowledged.

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		understanding of it.	
NE	11/12/17 PEIR Response – Point 16: Section 12.8 Cumulative impacts	It is not clear in this section what the reference population is for the assessment. Paragraph 673 states the MU is used as the population reference area but then results are provided in the context of the SCANS III North Sea Assessment Unit. As previously stated, Natural England consider the MU to be the appropriate reference population and assessment results should be presented in the context of the MU population.	The North Sea MU population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al.*, 2017) based on the SCANS-III data has been used as the reference population throughout the assessment. As outlined below, NE confirmed (letter date 03/01/18; Point 2) that it is appropriate to use the SCANS-III population data as the same area is used as the Management Unit.
NE	11/12/17 PEIR Response – Point 17: Para 699 – 700	Natural England is not quite sure which advice note is being referred to here, but it should be noted that the advice quoted here is SNCB advice and not just that of Natural England.	Amended.
NE	11/12/17 PEIR Response – Point 18: Table 12.80 and 12.81(and all subsequent CIA tables)	It is not clear why the UK and European OWF sites have been separated in to two different tables? If they are being assessed together, Natural England consider it would be much less confusing for them to be tabulated together.	Amended.
NE	11/12/17 PEIR Response – Point 19: Para 751	Natural England request that clarity is provided for the first bullet point as to what is considered a 'marine renewable development' as this technically includes OWFs but these are listed separately in the preceding paragraph.	Amended.
NE	11/12/17 PEIR Response – Point 20: Para 753	Natural England appreciate it is difficult to know at this time how many UXO detonations may be required prior to commencement or UXO survey works. However, we consider it to be possible to assess a certain quantity of detonations based on experience of similar sized projects in the southern North Sea.	The CIA is based on the number of potential UXO detonations that could potential occur at the same time, not the number of UXO that could be present with each site. The assessment of the potential UXO at Norfolk Vanguard has included a strategic UXO risk management assessment, presented in Appendix 5.2 and outlined in section 12.7.4.1.

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NE	11/12/17 PEIR Response – Point 21: Para 818 and 825	Natural England welcomes the opportunity for further discussion with Vattenfall regarding a Site Integrity Plan and a possible strategic approach to mitigation as part of the Evidence Plan process.	Further discussions regarding the Site Integrity Plan and a possible strategic approach to mitigation are ongoing with the SNCBs and MMO. The draft SIP has been issued to ETG and submitted with the DCO application (document 8.17).
NE	11/12/17 PEIR Response – Point 22: Para 854	Natural England would welcome the opportunity to work with Vattenfall on the Marine Mammal Mitigation Protocol (MMMP) for UXO as well as the MMMP for piling.	Further discussion regarding the MMMP will be conducted with the SNCBs and MMO. A draft MMMP for piling (document 8.13) is submitted with the DCO application
NE	11/12/17 PEIR Response – Appendix 10.4 Offshore HRA screening: Section 2.3.2.2 and 2.3.3.2	These sections state that the maximum impact to seals is TTS to 5.4 km based on the Southall *et al* (2007) criteria of 171 dB SEL. However, table 12.39 of Chapter 12 states the maximum impact to seals is PTS to 21km based on the Southall et al (2007) criteria of 186 bid SEL_{cum}. Clarification should be provided as to why this figure was not used in the screening.	The initial underwater noise modelling for the HRA screening was updated for the PEIR and has since been updated for the ES, to reflect changes in the project, updates in the modelling and EPP discussions. Therefore, there are differences between the different documents produced at different stages of the project. As outlined above, the current advice from Natural England is to use the NOAA (NMFS, 2016) thresholds and criteria.
NE	11/12/17 PEIR Response – Appendix 12.2 ADD Mitigation	No comment.	Acknowledged.
MMO	11/12/2017 PEIR Response – Point 6	Mitigation in all chapters, whilst reasonable, is generally of a standardised nature. The MMO would appreciate the opportunity to input into specific mitigation issues when further details emerge. At this stage, it has been difficult for the MMO and its advisers to fully assess the appropriateness of mitigation due to the generalised nature.	A draft MMMP for piling (document 8.13) and In Principle SIP (document reference 8.17) are submitted with the DCO application to outline the specific mitigation measures in relation to marine mammals.
MMO	11/12/2017 PEIR Response – Point 7	There is scarce information regarding assessed impacts regarding activities relating to the windfarm that is not construction and to a lesser extent operation. Related activities such as UXO clearance and boulder clearance and	Underwater noise modelling for UXO clearance at Norfolk Vanguard has been conducted and included in the ES – Section 12.7.4.1. Noise from other construction activities, such as

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		cable repair will inevitably be part of the impact of the whole project and should be given further consideration. For instance, we note that UXO activities have been included in noise modelling but not included in wider activities in the time line of the project. The MMO recommends that as much peripheral but essential activities are included in the assessment as possible to fully understand the impact of the whole project.	cable installation, has been assessed in section 12.7.4.3. Vessel noise has been assessed in section 12.7.4.4. Operational noise has been assessed in section 12.7.5.1.
MMO	11/12/2017 PEIR Response – Point 8: Nature Conservation	With regard to impacts on designated areas, namely the southern North Sea candidate Special Area of Conservation (cSAC), we defer to Natural England, as the statutory nature conservation body (SNCB). However, the MMO require a more detailed assessment of the potential impacts of the Project as required under the Conservation of Habitats and Species Regulations (2017) taking into account the conservation status and conservation objects of the site. The assessment must consider the proposed activities and either conclude with absolute certainty that there will be no Likely Significant Effects or assess the impacts through an Appropriate Assessment.	This has been as assessed as part of the Report to inform the HRA (document reference 5.3),
MMO	11/12/2017 PEIR Response – Point 59: Underwater noise	The MMO notes Vattenfall have followed the methodology approved through the evidence plan process.	Acknowledged.
MMO	11/12/2017 PEIR Response – Point 60: Underwater noise	Other noise generating activities such as increased vessel traffic, seabed preparation, rock dumping and cable installation should be assessed as well as impact piling which it is recognised will generate the highest level of underwater noise. The MMO notes that UXO noise has been included in the noise modelling however all operational and peripheral activities should be included in the assessment.	Underwater noise modelling for UXO clearance at Norfolk Vanguard has been conducted and included in the ES – Section 12.7.4.1. Noise from other construction activities, such as cable installation, has been assessed in section 12.7.4.3. Vessel noise has been assessed in section 12.7.4.4. Operational noise has been assessed in section 12.7.5.1.

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MMO	11/12/2017 PEIR Response – Point 61: Underwater noise	The MMO recommends that Vattenfall continue to employ NOAA guidance as adopted by Natural England and the Joint Nature Conservation Committee.	As agreed through the EPP, the NOAA (NMFS, 2016) thresholds and criteria have been used in the assessment for PTS and TTS in the ES chapter. The PTS/TTS thresholds from Southall *et al*. (2007) and Lucke *et al*. (2009) have been included in the additional assessments in Appendix 12.5.
MMO	11/12/2017 PEIR Response - Point 62: Underwater noise	Overall, an informative noise report has been produced detailing the fleeing animal models that have been used for marine mammals and fish, the propagation model and model parameters including the frequency content, environmental conditions and source levels. The propagation loss model used is an energy model. Therefore, it is not clear how the SPL_{peak} is derived, or how the maps in Figures 5-1 to 5-4 are produced within the PEIR. This should be clarified.	The model used is a combination parabolic equation/ray-tracing solution, and derives the SPL_{peak} levels from our noise measurement database that collects piling noise data, including measured SPL_{peak} and SEL, from over 50 datasets.
MMO	11/12/2017 PEIR Response - Point 63: Underwater noise	Furthermore, impact ranges are provided for SEL_{cum} and SEL_{ss}, in addition to the SPL_{peak}. However, the SEL source levels are not provided. Thus, it is not clear how the SEL received levels are derived from the propagation loss model and the SPL_{peak} source levels. This should be clarified.	The SEL source levels are derived from Subacoustech's measurement database, with the model tuned to empirical measurements sampled under similar conditions. A list of SEL_{ss} source levels will be included under table 4-4 in Appendix 5.3.
MMO	11/12/2017 PEIR Response - Point 64: Underwater noise	Figure 5-5 in the PEIR illustrates that the noise from pin piles contains more high frequency components than the noise from monopiles. It also shows the sound frequency spectra for monopiles and pin piles, adjusted (weighted) to account for the sensitivities of medium and high frequency cetaceans. These levels can be compared to the original unweighted frequency spectra in Figure 4-2 (shown faintly in Figure 5-5, below for reference). However, the levels provided in the figure are SPL_{peak}. The MMO understands the application of weighting is relevant for energy (or sound exposure level) but not for SPL_{peak}. This should be clarified.	The SEL metric is weighted to calculate the effects on marine mammals to NMFS or Southall guidelines. The graphs in Figure 5-5 of Appendix 5.3 are illustrative of the effect of the weighting and not used in the assessment, and we agree that SEL would be more relevant in this graph.

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MMO	11/12/2017 PEIR Response - Point 65: Underwater noise	Furthermore, it is not clear whether this weighting has been used in the actual modelling, or if it has just been used for illustration purposes in Figure 5-5. This should also be clarified.	All the NMFS modelling that uses these weightings for its cumulative criteria and are denoted as "weighted SEL_{cum}". The SPL_{peak} data in Figure 5-5 of Appendix 5.3 are for illustrative purposes only.
MMO	11/12/2017 PEIR Response - Point 66: Underwater noise	The MMO has encountered situations where soft starting procedures have not been possible where the piling operations have been interrupted. The MMO require that this issue is considered during the development of marine mammal mitigation. Likewise there have been issues with specific levels of soft start (10% of maximum hammer energy) not being feasible in practice and this should be taken in to account. The proposed mitigation included in the Marine Mammal Protocol will need to be supported with robust evidence.	Marine mammal mitigation will be developed through the MMMP in consultation with the MMO.
MMO	11/12/2017 PEIR Response - Point 67: Underwater noise	A minor point is that the model uses two solvers, one for low frequencies and one for higher frequencies. An assumption has been made that the propagation loss model uses the parabolic equation up to the first 1/3 octave band centred at 250 Hz, and the ray tracing method from the next 1/3 octave band centred at 315 Hz. Please confirm this.	This is correct for the modelling used in the ES (however this is not relevant to the INSPIRE modelling, which is a semi-empirical solution rather than purely numerical solvers.)
MMO	11/12/2017 PEIR Response - Point 68: Underwater noise - potential mitigation which could be included in the DCO	In addition to the mitigation already mentioned including soft start and 24 hour working, a Marine Mammal Mitigation Plan (MMMP) will be developed in consultation with key stakeholders. This will include monitoring where appropriate.	As outlined in section 12.12.1, the MMMP for piling will be developed in the pre-construction period and based upon best available information and methodologies. The MMMP for piling will be produced in consultation with Natural England, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury to marine mammals during all piling operations. A draft MMMP (document reference 8.13) is submitted with the DCO application. An In Principle Monitoring Plan (document reference 8.12) is provided with the DCO application to outline the proposed monitoring and

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			the basis of delivering the monitoring measures as required by the conditions contained within the Deemed Marine Licences (DMLs). This will be developed and discussed with the SNCBs and MMO.
MMO	11/12/2017 PEIR Response - Point 69: Underwater noise - potential mitigation which could be included in the DCO	The embedded mitigation is detailed in section 12.7.1 of the Marine Mammal chapter and will include a soft start protocol and a mitigation zone. Details of soft start procedure should include the lowest possible operating hammer energy if this is above the 10% of the maximum hammer energy which is the standard soft start level.	The soft-start will be 10% (or less) of the maximum hammer energy.
MMO	11/12/2017 PEIR Response - Point 70: Underwater noise - potential mitigation which could be included in the DCO	ADDs should be given careful consideration, particularly as they introduce additional acoustic disturbance. However, we note that information will be reviewed and updated with the latest information for all suitable devices that are available when the Marine Mammal Mitigation Plan (MMMP) is prepared post-consent and prior to construction.	A review of all appropriate and suitable mitigation options will be conducted for the MMMP prior to construction.
MMO	11/12/2017 PEIR Response - Point 71: Marine Mammals	In general, the MMO will defer to our specialists at Natural England and Cefas however the following points should be addressed.	Acknowledged.
MMO	11/12/2017 PEIR Response - Point 72: Marine Mammals	An embedded mitigation of soft start piling has been described. The MMO recommends that a soft start piling of 40 minutes be discussed with Natural England as this may not be appropriate in all circumstances. Details of hammer energy and feasibility of achieving the desired 10% of maximum should be discussed when details of the hammer are known.	The minimum potential soft-start and ramp-up period of 30 minutes has been used in the assessment (which is greater than the recommended minimum of 20 minutes). The soft-start will be 10% (or less) of the maximum hammer energy for a minimum of 10 minutes. As a worst-case scenario, the minimum potential soft-start of 10 minutes and minimum ramp-up period of 30 minutes was used in the noise modelling for PTS SEL_{cum}.
MMO	11/12/2017 PEIR Response - Point 73: Marine Mammals	In assessing the risk of collision, it is stated that this will be mitigated against using a vehicle management plan and best practice. The vehicle management plan, in common with	There will not be any commitments associated with vessel routing, speeds etc as no mitigation is required or proposed.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		other plans mentioned such as Environmental Management plans and a Marine Mammal Mitigation Plan, will need to be captured in the licence however it is unclear how best practice will be secured.	
MMO	11/12/2017 PEIR Response - Point 74: Marine Mammals	Page 114 Point 397 of the PEIR suggests that mammals may not move away from all pile noise in 100% of all cases as an illustration that disturbance is less than the worst case. Has this element been factored into the modelling and mitigation for UXO works?	The assessment of the potential impacts of UXO clearance includes the noise modelling for PTS and TTS based on NOAA (NMFS, 2016) and that all marine mammals within a 26km radius could be disturbed. For piling the threshold of possible avoidance based on the Lucke *et al*. (2009) criteria has been assessed for harbour porpoise and the assessment takes into account that not all harbour porpoise in this potential impact range could be disturbed.
TWT	08/12/17 PEIR Response - 3.1: Impact assessment methodology	After reviewing the marine mammal sensitivity assessment criteria used across a range of offshore wind farms, we have concerns regarding inconsistencies in approaches. TWT will be reviewing this in more detail in the New Year and will be happy to speak to Vattenfall about any concerns we have regarding assessment methodology used as part of the Environmental Impact Assessment.	It is acknowledged that The Wildlife Trust have raised concerns over the marine mammal sensitivity assessment criteria used across a range of offshore wind farms and inconsistencies in approaches. However, it was agreed on the EPP call (08/12/17) that the proposed approach is currently suitable.
TWT	08/12/17 PEIR Response - 3.2. Embedded mitigation: soft start	Paragraph 205 of the PEIR outlines "*During the 60 minutes for the soft-start and ramp-up it is estimated that animals would move over 5.4km from the piling location (based on a precautionary average marine mammal swimming speed of 1.5m/s)*." A breakdown of fleeing distance for each ramp up level would be useful to provide certainty that marine mammals would be beyond the zone before each ramp up.	As a precautionary approach the minimum potential soft-start and ramp-up period of 30 minutes has been used in the assessment for the ES. A breakdown of the distances has been provided in Section 12.7.1.
TWT	08/12/17 PEIR Response - Appendix 12.2: Acoustic Deterrent Devices	We have reviewed Appendix 12.2 of the PEIR; Acoustic Deterrent Devices (ADDs) as Effective Mitigation for Marine Mammals. However, there is little information on the long terms effects ADDs such as habituation and the additional disturbance effects from their use, especially contributing to	All current and relevant information has been reviewed; however, JNCC is currently preparing a report on ADDs which, when available, will be taken into account, along with the latest information and guidance, when preparing the

Consultee	Date / Document	Comment	Response / where addressed in the ES
		temporal impacts. TWT is pleased to see that ADDs are being taken into account as part of the assessment.	MMMP.
TWT	08/12/17 PEIR Response - 3.3.1. Disturbance: return times	The durations of any potential displacement effects are discussed in 12.7.3.2.5 of the PEIR. We highlight that there is not enough evidence to understand the true nature of harbour porpoise return behaviour following piling activity. Previous studies do highlight differing return times but we have no certainty if these are the same animals returning or new animals visiting the site. We do not know how much site fidelity relates to return times e.g. quicker return times due to good foraging areas (Brandt *et al* (2016)) which could result in risking overall fitness due to potential multiple flight activity from multiple piling events (Dahne *et al* (2013)).	The information in section 12.7.4.2.4 has been reviewed to address this.
TWT	08/12/17 PEIR Response - 3.3.1. Disturbance: return times	There is also the consideration of other noise producing activities which take place during the construction period that can affect return times. Brandt *et al* (2016) suggest that "effects lasting beyond the piling time may not only be a result of piling activities, but also of other construction activities resuming after the end of piling, such as demounting noise mitigation systems and the increased shipping activity that goes with it. One factor that points towards this is that detection rates were already decreased for some time before piling."	The information in section 12.7.4.2.4 has been reviewed to address this.
TWT	08/12/17 PEIR Response - 3.3.2. Impact 4: Vessel underwater noise and disturbance	Heinänen and Skov (2015) report that responses to the number of ships per year indicate markedly lower densities with increasing levels of traffic. A threshold level in terms of impact seems to be approximately 20,000 ships/year (approx. 80/day). Already the shipping levels are quoted in paragraph 519 to be in the *"the summer period of the marine traffic survey, there was on average 69 unique vessels per day recorded within NV East, 46 unique vessels per day recorded within the NV West and on average 96 unique vessels per day recorded within the offshore cable corridor.*	Reference to the threshold level of impact related to number of vessels (approximately 20,000 ships per year) in Heinänen and Skov (2015) has been used in the assessment in section 12.7.3.4.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		Throughout the winter period of the marine traffic survey, there was on average 63 unique vessels per day recorded within the NV East, 39 unique vessels per day recorded within the NV West and on average 92 unique vessels per day recorded within the offshore cable corridor." The impact of increased shipping movement should be considered in more detail against this information. This is of particular importance for the cumulative assessment, of which existing vessel movements should be taken into account as part of the assessment.	
TWT	08/12/17 PEIR Response - 3.4: Cumulative impact assessment	Fishing must be included in the cumulative impact assessment. This is based on a precedent set when TWT began Judicial Review proceedings against the Department for Energy and Climate Change in August 2015 against the approval of Dogger Bank Offshore Wind Farm Order due to the exclusion of fishing from the in-combination assessment as part of the HRA. Fishing is a licensable activity and according to the Waddenzee case[2], the regular grant of licenses constitutes a plan or a project. Although our position remained, TWT withdrew the claim due to assurances given by the government regarding the management of fishing within Dogger Bank SAC. One of those assurances was that steps would be put in place to ensure that this scenario would not happen again and that Defra and DECC would work together to ensure fishing would be included in future offshore wind farm impact assessments. Although our challenge was in relation to the lack of inclusion of fishing as part of the HRA assessment, the same principle should apply to the EIA cumulative assessment.	Fishing activity is considered part of the existing baseline, as it has existed in the North Sea for a long time before any OWF construction, it is not a recent or an increasing activity (in most areas fishing is currently in decline). It is more appropriate for fishing to be assessed as part of a more strategic assessment rather than project / developer led assessment.

[2] C-127/02 Wadenzee [2004] ECR 1-7405

Consultee	Date / Document	Comment	Response / where addressed in the ES
TWT	08/12/17 PEIR Response - 3.4: Cumulative impact assessment	We are in agreement with paragraph 715 that due to uncertainty in project level CIAs, a strategic approach to assessment is required. Different approaches to assessment are taken by offshore developers using different noise criteria and thresholds and different assessment. A strategic approach would ensure consistency, produce more realistic outcomes and provide industry with more certainty on mitigation requirements.	As outlined in section 12.8.3, the level of uncertainty in completing a CIA further supports the need for a more strategic assessment rather than developer led assessment. Norfolk Vanguard Limited is supportive of these strategic initiatives, and will continue to work alongside other developers, Regulators and SNCBs in order to further understand the potential for significant cumulative impacts, and lead to reductions in impacts where appropriate.
TWT	08/12/17 PEIR Response - 3.4: Cumulative impact assessment	A number of different CIA scenarios have been presented in tables 12.80 to 12.83 of the PEIR, with the magnitude impacts ranging from high to low. Following the discussion with the Marine Mammal Expert Topic Group, we agree that, for clarity, the most likely worst-case scenario should be presented.	As agreed the most 'likely scenario' for the potential worst-case for the CIA has been assessed in the ES chapter. The theoretical worst-case and other scenarios have been assessed in Appendix 12.6.
TWT	08/12/17 PEIR Response - 3.5: Foundation types	Chapter 5 of the PEIR has identified that a number of foundation types are being considered as part of the project design envelope. In order to meet the requirements of the Habitats Directive in terms of FCS of protected sites and the Marine Strategy Framework Directive descriptor 11, TWT believe that there must be a move away from pile driving to reduce noise pollution in the marine environment. To meet Article 6(4) of the Habitats Directive, it is essential that an assessment of alternative foundation types to piling is undertaken to provide justification for the need for pile driving during construction. The alternatives assessment is also a key element of the environmental impact assessment when applying for an EPS licence post-consent.	A number of foundation types are being considered as part of the project design envelope and have been assessed, where relevant, in the ES. The most suitable foundation options for the site would be determined during final design, post consent, and would be informed by further site investigations.
TWT	08/12/17 PEIR Response - 3.6: Approach to the Habitats Regulations	It is important that a site based approach is undertaken to the Southern North Sea cSAC HRA assessment. TWT does not support the Interagency Marine Mammal Working Groups (IAMMWG) proposal on underwater management in its	As agreed, an additional assessment has been included in Appendix 12.4, for information, based on the estimate that the SNS cSAC could support 29,384 harbour porpoise (SCANS-III data for 17.5%

Consultee	Date / Document	Comment	Response / where addressed in the ES
	Assessment (HRA) noise assessment	current form. We do not think the evidence which the thresholds are based upon is appropriate and therefore not precautionary enough. TWT, along with WWF, ClientEarth and Whale and Dolphin Conservation have produced a working document describing our collective views of underwater noise assessment and management, which is included in Appendix A and B. The paper advocates the use of noise limits to assess and manage impacts from underwater noise, which would continue to ensure a site based approach. We are currently engaging with Renewables UK to gain an industry perspective on the paper. We would also be happy to discuss the paper with Vattenfall directly.	of the UK North Sea MU). A separate appendix will also be included with the Report to inform the HRA (document reference 5.3), As outlined, in section 12.12.1, the MMMP for piling will be developed in the pre-construction period and based upon best available information and methodologies. The MMMP for piling will be produced in consultation, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury to marine mammals during all piling operations.
TWT	08/12/17 PEIR Response - 3.7: Monitoring	Since the designation of Southern North Sea cSAC, more monitoring on the impacts of offshore wind farm on harbour porpoise is required. Monitoring should involve pre-construction, construction and post-construction monitoring of noise levels. In addition to this, a programme of harbour porpoise monitoring is required, again pre-construction, construction and post-construction, to understand harbour porpoise distribution and the impacts of wind farm development upon this. We are happy to discuss this in more detail with Vattenfall.	An In Principle Monitoring Plan (document reference 8.12) is provided with the DCO application to outline the proposed monitoring and the basis of delivering the monitoring measures as required by the conditions contained within the DMLs. The details of the monitoring methodologies will be developed in consultation with the SNCBs and MMO.
Eastern IFCA	11/12/17 PEIR Response - 3.1.2 Southern North Sea cSAC	Sandeels are among the most important prey species for harbour porpoise. Sandeels rely on sandbanks and other sandy substrata similar to those found in the Haisborough, Hammond and Winterton SCI (Ellis *et al*., 2012). There is a potential pathway for the species to be impacted by the construction and operational work, as well as by the habitat loss associated with unburied, protected cable, however the PEIR has identified these as not significant. This should be further considered to address the cumulative impacts of the project on sandeels with other plans and projects in the Southern North Sea.	Potential impacts on marine mammal prey species, including sandeels, have been assessed in Chapter 11 Fish and Shellfish Ecology using the appropriate realistic worst-case scenarios for these receptors.

Consultee	Date / Document	Comment	Response / where addressed in the ES
Eastern IFCA	11/12/17 PEIR Response - 3.1.2 Southern North Sea cSAC	The PEIR concluded that the cumulative underwater noise caused by pile driving during the construction of Norfolk Vanguard, in-combination with similar activities occurring at the same time, could potentially impact on harbour porpoise over a wide area. Eastern IFCA asks that further consideration of mitigation measures to protect these species is made prior to the construction of the windfarm. We defer to Natural England for formal conservation advice on this matter.	As outlined, in section 12.12.1, the MMMP for piling will be developed in the pre-construction period and based upon best available information and methodologies. The MMMP for piling will be produced in consultation, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury to marine mammals during all piling operations. In addition to the MMMP, a Norfolk Vanguard Southern North Sea cSAC Site Integrity Plan will be developed. The Plan will set out the approach to deliver any project mitigation or management measures in relation to harbour porpoise and the SNS cSAC. A draft MMMP for piling (document reference 8.13) is submitted with the DCO application
Ministry of Infrastructure and Water Management Netherlands	11/12/2017 PEIR Response	The impact on the marine mammals due to disturbance is described as the number of animals impacted by one instance of an event. This is then classified according to the criteria mentioned in the PEIR. However the consequences for the population aren't calculated. This makes it difficult to determine the cumulative effects other than qualitatively. As this is the preliminary impact assessment, we hope (and expect) that population consequences will be calculated in the next phase of the environmental impact assessment.	As outlined in section 12.8.3, population models, such as Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea (DEPONS) and the interim Population Consequences of Disturbance (iPCoD) used at a strategic level would allow consideration of the biological fitness consequences of disturbance from underwater noise, and the conclusions of a quantitative assessment to be put into a population level context. Norfolk Vanguard Limited is supportive of these strategic initiatives, and will continue to work alongside other developers, Regulators and SNCBs in order to further understand the potential for significant cumulative impacts, and lead to reductions in impacts where appropriate.

Consultee	Date / Document	Comment	Response / where addressed in the ES
Ministry for the Environment, France	11/12/2017 PEIR Response	It is important to note the negative effects of underwater noise from piling on marine mammals during the building phase. Indeed, other wind farms could be constructed at the same time by creating huge cumulative impacts on these marine mammals.	The cumulative impacts of the construction of other offshore windfarms at the same time as Norfolk Vanguard has been assessed in section 12.8.
Ministry for the Environment, France	11/12/2017 PEIR Response	With a maximal power of 20Mw, some turbines will generate electromagnetic interference far more important than standard turbines with a capacity of 7Mw by contributing to disturb the sense of direction of marine mammals until their beaching along the coast.	Although it is assumed that harbour porpoise and other marine mammals are capable of detecting small differences in magnetic field strength, there is, at present, no evidence to suggest that existing subsea cables have influenced cetacean movements. Harbour porpoise move in and out of the Baltic Sea with several crossings over operating subsea HVDC cables in the Skagerrak and western Baltic Sea without any apparent effect on their migration pattern (Walker, 2001). There is no evidence that pinnipeds respond to electromagnetic fields (Gill *et al*., 2005). Data from operational windfarms show no evidence of exclusion of harbour porpoise or seals (for example, Diederichs *et al*., 2008; Lindeboom *et al*., 2011; Marine Scotland, 2012; McConnell *et al*., 2012; Russell *et al*., 2014; Scheidat *et al.,* 2011; Teilmann *et al*., 2006; Tougaard *et al*., 2005, 2009a, 2009b).
NE	03/01/2018 – Point 2: Technical Advice	Use of SCANS III population data: We can confirm that it is appropriate to use the SCANS III population data as the same area is used as the Management Unit. Vattenfall should ensure that the following abundances are used: North Sea MU harbour porpoise abundance 345,373 (CV – 0.18, CL low – 246,526 and CL high 495,752).	The North Sea MU population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al*., 2017) based on the SCANS-III data has been used as the reference population throughout the assessment.
NE	03/01/2018 – Point 3: Technical Advice	Whether fisheries should be assessed as a plan or project: At the meeting held on the 8th Dec 2017 it was discussed whether commercial fisheries should be considered a plan or	Fishing activity is considered part of the existing baseline, as it has existed in the North Sea for a long time before any OWF construction, it is not a

Consultee	Date / Document	Comment	Response / where addressed in the ES
		project or remain as part of the baseline.	recent or an increasing activity (in most areas fishing is currently in decline). It is more appropriate for fishing to be assessed as part of a more strategic assessment rather than project / developer led assessment.
NE	03/01/2018 – Point 7: Technical Advice	Marine mammal swimming speed in response to proposed mitigation and PTS cumulative SEL exposure: We note that this is a different approach to other EIAs and HRAs, but we are content to consider the increased marine mammal swimming speed of 1.8m/s (rather than the standard 1.5m/s) providing adequate evidence is provided as justification supporting this approach and is not used for assessing disturbance in the EIA.	The SEL_{cum} in the noise modelling has been based on the average swimming speed of 1.5m/s (Otani *et al*., 2000), as a precautionary approach. However, where relevant the assessment also includes reference to a swimming speed of 1.8m/s, which is more representative of a fleeing animal (e.g. Kastelein *et al*. (2018) recorded swimming speeds of 1.97m/s during playbacks of pile driving sounds).
NE, MMO, The Wildlife Trust, and WDC	26th March 2018 - Evidence Plan Process for Marine Mammals Meeting	A conference call to discuss feedback on the HRA	Discussion of feedback on the draft Report to inform the HRA for marine mammals.

12.4 Assessment Methodology

12.4.1 Impact Assessment Methodology

57. A matrix approach has been used to assess impacts following best practice, EIA guidance and the approach outlined in the Norfolk Vanguard Scoping Report (Royal HaskoningDHV, 2016) and the Marine Mammal Method Statement (Royal HaskoningDHV, 2017a).The data sources summarised in section 12.5.2 were used to characterise the existing environment (see section 12.6). Each potential impact has been identified using expert judgement and through consultation with Statutory Nature Conservation Bodies (SNCBs) via the Scoping Process and EPP. An assessment of the significance is then made based on the sensitivity, value and magnitude of effect, the definitions of which were also agreed in consultation during the EPP (see Table 12.4).

12.4.1.1 Sensitivity

58. The sensitivity of a receptor is determined through its ability to accommodate change and on its ability to recover if it is negatively affected. The sensitivity level of marine mammals to each type of impact is justified within the impact assessment and is dependent on the following factors:

- Adaptability – The degree to which a receptor can avoid or adapt to an effect;
- Tolerance – The ability of a receptor to accommodate temporary or permanent change without a significant adverse effect;
- Recoverability – The temporal scale over and extent to which a receptor will recover following an effect; and
- Value – A measure of the receptors importance and rarity (as reflected in the species conservation status and legislative importance, see section 12.4.1.2).

59. The sensitivity of marine mammals to impacts from pile driving noise is currently the impact of most concern across the offshore wind sector. The sensitivity to potential impacts of lethality, physical injury, auditory injury or hearing impairment, as well as behavioural disturbance or auditory masking will be considered for each species, using available evidence including published data sources. Table 12.5 defines the levels of sensitivity and what they mean for the receptor.

Table 12.5 Definitions of sensitivity levels for marine mammals

Sensitivity	Definition
High	Individual receptor has very limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Medium	Individual receptor has limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.

Sensitivity	Definition
Low	Individual receptor has some tolerance to avoid, adapt to, accommodate or recover from the anticipated impact.
Negligible	Individual receptor is generally tolerant to and can accommodate or recover from the anticipated impact.

12.4.1.2 Value

60. In addition, the 'value' of the receptor forms an important element within the assessment, for instance, if the receptor is a protected species. It is important to understand that high value and high sensitivity are not necessarily linked. A receptor could be of high value, but have a low or negligible physical/ecological sensitivity to an effect. Similarly, low value does not equate to low sensitivity and is judged on a receptor by receptor basis.

61. In the case of marine mammals, a large number of species fall within legislative policy; all cetaceans in UK waters are EPS and, therefore, are internationally important. Harbour porpoise, bottlenose dolphin, grey seal and harbour seals are also afforded international protection through the designation of Natura 2000 sites. As such, all species of marine mammal can be considered to be of high value.

62. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement. Table 12.6 provides definitions for the value afforded to a receptor based on its legislative importance.

Table 12.6 Definitions of value levels for marine mammals

Value	Definition
High	Internationally or nationally important
Medium	Regionally important or internationally rare
Low	Locally important or nationally rare
Negligible	Not considered to be particularly important or rare

12.4.1.3 Magnitude

63. The significance of the potential impacts is also based on the intensity or degree of disturbance to the baseline conditions and is categorised into four levels of magnitude: high; medium; low; or negligible, as defined in Table 12.7.

64. The thresholds defining each level of magnitude of effect for each impact have been determined using expert judgement, current scientific understanding of marine mammal population biology and JNCC *et al*. (2010) draft guidance on disturbance to EPS species. The magnitude of each effect is calculated or described in a quantitative or qualitative way within the assessment.

65. The number of animals that can be 'removed' from a population through injury or disturbance will vary between species, but is largely dependent on the growth rate of the population; populations with low growth rates can sustain the removal of a smaller proportion of the population. The JNCC *et al*. (2010) draft guidance provides some indication on how many animals may be removed from a population without causing detrimental effects to the population at FCS. The JNCC *et al*. (2010) draft guidance also provides limited consideration of temporary effects, with guidance reflecting consideration of permanent displacement. As such this guidance has been considered in defining the thresholds for magnitude of effects.

66. Temporary effects are considered to be of medium magnitude at greater than 5% of the reference population being affected within a year. JNCC *et al*. (2010) draft guidance considered 4% as the maximum potential growth rate in harbour porpoise, and the 'default' rate for cetaceans. Therefore, beyond natural mortality, up to 4% of the population could theoretically be permanently removed before population growth would be halted. In assigning 5% to a temporary impact in this assessment, consideration is given to uncertainty of the individual consequences of temporary disturbance.

67. Permanent effects to greater than 1% of the reference population being affected within a year are considered to be high magnitude in this assessment. The assignment of this level is informed by the JNCC *et al*. (2010) draft guidance (suggesting 4% as the 'default maximum growth rate for cetaceans) but also reflects the large amount of uncertainty in the potential individual and population level consequences of permanent effects.

Table 12.7 Definitions of magnitude levels for marine mammals

Magnitude	Definition
High	Permanent irreversible change to exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >1% of the reference population are anticipated to be exposed to the effect. OR Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the project). Assessment indicates that >5% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >10% of the reference population are anticipated to be exposed to the effect.
Medium	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that between >0.01% and <=1% of the reference population anticipated to be exposed to effect.

Magnitude	Definition
	OR Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the project). Assessment indicates that >1% and <=5% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that between >5% and <=10% of the reference population anticipated to be exposed to effect.
Low	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that between >0.001 and <=0.01% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the project). Assessment indicates that >0.01% and <=1% of the reference population are anticipated to be exposed to the effect. OR Intermittent and temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that between >1% and <=5% of the reference population anticipated to be exposed to effect.
Negligible	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that <=0.001% of the reference population anticipated to be exposed to effect. OR Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the project). Assessment indicates that <=0.01% of the reference population are anticipated to be exposed to the effect. OR Intermittent and temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that <=1% of the reference population anticipated to be exposed to effect.

12.4.1.4 Impact significance

68. Following the identification of receptor sensitivity and the magnitude of the effect, the impact significance is determined using expert judgement. The probability of the impact occurring is also considered in the assessment process. If doubt exists concerning the likelihood of occurrence or the prediction of an impact, a

precautionary approach is taken to assign a higher level of probability to adverse effects.

69. The matrix (provided in Table 12.8) will be used as a framework to aid determination of the impact assessment. Definitions of impact significance are provided in Table 12.9. For the purposes of this ES and specifically the marine mammal assessment, major and moderate impacts are deemed to be significant. However, whilst minor impacts would not be deemed significant in their own right, they may contribute to significant impacts cumulatively or through inter-relationships.

Table 12.8 Impact significance matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 12.9 Impact significance definitions

Impact Significance	Definition
Major	Very large or large change in receptor, either adverse or beneficial, which are important at a population (national or international) level because they contribute to achieving national or regional objectives, or, expected to result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate or large change in receptor, which may be important considerations at national or regional population level. Potential to result in exceedance of statutory objectives and / or breaches of legislation.
Minor	Small change in receptor, which may be raised as local issues but are unlikely to be important at a regional population level.
Negligible	No discernible change in receptor.

12.4.2 Cumulative Impact Assessment

70. The Cumulative Impact Assessment (CIA) identifies areas where the predicted impacts of the construction, operation, maintenance and decommissioning of the project could interact with impacts from different industry sectors within the same region and impact sensitive receptors.

71. The Planning Inspectorate (2012) Advice Note 9 states that:

"In assessing cumulative impacts, other major developments should be identified through consultation with the local planning authorities and other relevant authorities on the basis of those that are:

- *Under construction;*
- *Permitted application(s) but not yet implemented;*
- *Submitted application (s) but not yet determined;*
- *Projects on the 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 other plans and programmes (as appropriate) which set the framework for future development consent/approvals, where such development is reasonably likely to come forward".*

72. These stages of project development have been adopted as 'Tiers' of project development status within the cumulative impact assessment. These Tiers are based on guidance issued by JNCC and Natural England in September 2013, as follows:

- Tier 1: built and operational projects;
- Tier 2: projects under construction plus Tier 1 projects;
- Tier 3: projects that have been consented (but construction has not yet commenced) plus Tiers 1 and 2;
- Tier 4: projects that have an application submitted to the appropriate regulatory body that have not yet been determined, plus Tiers 1-3;
- Tier 5: projects that the regulatory body are expecting to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects), plus Tiers 1-4; and
- Tier 6: projects that have been identified in relevant strategic plans or programmes plus Tiers 1-5.

73. The types of plans and projects to be taken into consideration are:

- Other offshore wind farms;
- Other renewables developments;
- Aggregate extraction and dredging;
- Licenced disposal sites;
- Shipping and navigation;
- Planned construction sub-sea cables and pipelines;

- Potential port/harbour development;
- Oil and gas development and operation, including seismic surveys; and
- Unexploded ordnance (UXO) clearance.

74. The CIA is a two part process in which an initial list of potential projects is identified with the potential to interact with Norfolk Vanguard based on the mechanism of interaction and spatial extent of the reference population for each marine mammal receptor. Following a tiered approach, the list of projects is then refined based on the level of information available for this list of projects to enable further assessment.

75. The plans and projects screened in to the CIA are:

(1) Located in the marine mammal management unit (MU) population reference area (defined for individual species in the assessment sections);

(2) Offshore wind farm and other renewable developments, if there is the potential that the construction period could overlap with the proposed Norfolk Vanguard project. This has been based on the date of consent, following which the projects could be constructed (a highly precautionary approach); and

(3) Offshore wind farm and other renewable developments, if the construction and / or piling period could overlap with the proposed Norfolk Vanguard project, based on best available information on when the developments are likely to be constructed and piling (a more realistic approach and indicative scenario).

76. The CIA will consider projects, plans and activities which have sufficient information available in order to undertake the assessment. Insufficient information will preclude a meaningful quantitative assessment, and it is not appropriate to make assumptions about the detail of future projects in such circumstances.

77. The project Tiers considered in the CIA for marine mammals are outlined in Table 12.10.

Table 12.10 Tiers in relation to project category which have been screened into the CIA

Project category	UK	Other
Other offshore wind farms	Tier 1,2,3,4	Tier 1,2,3
Other renewable developments (tidal and wave)	Tier 1,2,3,4	Tier 1,2,3
Aggregate extraction and dredging	Tier 1,2,3	Screened out
Oil and Gas installations (including surveying)	Tier 1,2,3	Screened out
Navigation and shipping	Tier 1,2,3	Screened out
Planned construction of sub-sea cables and pipelines	Tier 1,2,3	Screened out
Licenced disposal sites	Tier 1,2,3	Screened out

12.4.3 Transboundary Impact Assessment

78. The potential for transboundary impacts has been addressed by considering the reference populations and potential linkages to non-UK sites as identified through telemetry studies.

79. The assessment of the effect on the integrity of the transboundary European sites as a result of impacts on the designated marine mammal populations has been undertaken and presented in the Report to inform the HRA (document reference 5.3)

12.5 Scope

12.5.1 Study Area

80. Marine mammals are highly mobile and transitory in nature, therefore it is necessary to examine species occurrence not only within the Norfolk Vanguard site, but also over the wider North Sea region. For each species of marine mammal, the following study areas have been defined based on the relevant Management Units (MUs), current knowledge and understanding of the biology of each species; taking into account the feedback received during consultation:

- Harbour porpoise North Sea (NS) MU;
- White-beaked dolphin Celtic and Greater North Seas MU;
- Minke whale Celtic and Greater North Seas MU;
- Grey seal South-east England, North-east England and UK East Coast MUs, and the Waddenzee region; and
- Harbour seal South-east England MU and the Waddenzee region.

81. The status and activity of marine mammals known to occur within or adjacent to Norfolk Vanguard is considered in the context of regional population dynamics at the scale of the southern North Sea, or wider North Sea, depending on the data available for each species and the extent of the agreed reference population.

12.5.2 Data Sources

82. Information to support the EIA is based on 32 months of survey data for NV East and 24 months of survey data for NV West, as agreed through the EPP (Marine Mammal ETG meeting, February 2017).

83. APEM collected high resolution aerial digital still imagery for marine mammals (combined with ornithology surveys) over both the Norfolk Vanguard OWF sites and a 4km buffer around each site covering an area of 645km^2 (see Appendix 12.1). The surveys capture imagery at 2cm Ground Sampling Distance (GSD). Coverage of the

site and 4km buffer was between approximately 11% and 13% per month. All images were analysed to enumerate marine mammals to species level, where possible (see Appendix 12.1 for further details).

84. The aerial surveys were designed specifically to collect adequate and robust data on both marine mammals and birds across the Norfolk Vanguard OWF sites and a 4km buffer around each site. Aerial surveys have been used in the SCANS surveys, including the SCANS-III surveys to estimate cetacean abundance (Hammond *et al*., 2017).

85. The technology underlining aerial digital methods for surveying marine mammals has evolved considerably in recent years and several independent studies have justified the growing confidence in the emerging use of digital survey methods (Voet *et al*., 2017; Lowry, 1999; Koski *et al*., 2013; Stewart *et al*., 2013). The improvement of digital sensors and enhancement of imagery resolution now allows for the monitoring of large areas at a small ground sampling distance (Voet *et al*., 2017). Additionally, perception or detection bias can be minimised and the production of permanent records allows species identification, group size and behaviour to be re-analysed. During aerial surveys, marine mammals can be seen not only when breaking the surface, but when below the surface as well. Under normal conditions, harbour porpoises are available for detection during aerial surveys when in the top two metres of the water column (Teilmann *et al*., 2007, 2013). Therefore, correction factors have been applied to take into account the animals that are submerged, so that robust density estimates can be calculated (as outlined in Appendix 12.1 and section 12.6.1.1.3).

86. The following monthly aerial surveys have been undertaken of the Norfolk Vanguard site to characterise the site for marine mammals:

- APEM aerial survey data of the former East Anglia FOUR site (now NV East) with 4km buffer between March 2012 and February 2014;
- APEM aerial survey data of NV East with 4km buffer from September 2015 to April 2016 (as agreed with Natural England); and
- APEM aerial survey data of NV West with 4km buffer from September 2015 to August 2017.

87. Marine mammal data has also been collected during the extensive aerial surveys across the former East Anglia Zone. The following surveys encompass or overlap with Norfolk Vanguard:

- The Crown Estate Enabling Action data (video aerial survey) from November 2009 to March 2010, completed by HiDef Aerial Surveying Ltd; and

- APEM aerial survey data of the former Zone from April 2010 to April 2011).

88. In addition, the surveys for other offshore wind farms in the former Zone; East Anglia ONE (boat based surveys May 2010-April 2011 and APEM aerial surveys April 2010-October 2011) and East Anglia THREE (APEM aerial surveys September 2011-August 2013) provide useful context.

89. Further to the surveys within the former Zone, a range of information is available and which has informed the EIA, including, but not limited to:

- Small Cetaceans in the European Atlantic and North Sea (SCANS-III): Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys (Hammond *et al*., 2017);
- Small Cetaceans in the European Atlantic and North Sea (SCANS-II): Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management (Hammond *et al.,* 2013);
- Management Units for cetaceans in UK waters (Inter-Agency Marine Mammal Working Group (IAMMWG), 2015));
- Offshore Energy Strategic Environmental Assessment (including relevant appendices and technical reports) (Department of Energy and Climate Change (DECC) (now BEIS, 2016);
- The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area (Heinänen and Skov, 2015);
- Revised Phase III data analysis of Joint Cetacean Protocol (JCP) data resources (Paxton *et al*., 2016);
- Seasonal habitat-based density models for a marine top predator, the harbour porpoise, in a dynamic environment (Gilles *et al*., 2016);
- Survey for small cetaceans over the Dogger Bank and adjacent areas in summer 2011 (Gilles *et al*., 2012);
- Distributions of Cetaceans, Seals, Turtles, Sharks and Ocean Sunfish recorded from Aerial Surveys 2001-2008 (The Wildfowl & Wetlands Trust (WWT), 2009);
- MARINElife surveys from ferries routes across the southern North Sea area (MARINElife, 2017);
- Sea Watch Foundation volunteer sightings off eastern England (Sea Watch Foundation, 2017);
- Seal count data at Horsey haul-out sites during breeding season (Friends of Horsey Seals, 2017/2018);
- Norfolk bird and mammal reports (Norfolk and Norwich Naturalist Society, 2017);
- Aerial survey reports of harbour and grey seals counts in the Wadden Sea (Trilateral Seal Expert Group (TSEG), 2017);

- Seal telemetry data (e.g. Sharples *et al*., 2008; Russel and McConnell, 2014);
- UK seal at sea density estimates and usage maps (Russell *et al*., 2018); and
- Special Committee on Seals (SCOS) annual reporting of scientific advice on matters related to the management of seal populations (e.g. SCOS, 2017).

90. Consultation with key marine mammal stakeholders was conducted throughout the EIA as part of the EPP and included discussion of the best available information to use in the ES.

12.5.3 Assumptions and Limitations

91. Due to the large amount of data that has been collected during the Zone Environmental Appraisal (ZEA) and site specific surveys for Norfolk Vanguard, as well as other projects in the former Zone and other available data for marine mammals within the region, there is a good understanding of the existing environment. There are however some limitations to marine mammal surveys, primarily due to the highly mobile nature of marine mammals and therefore the potential variability in usage of the site; each survey provides only a snapshot. However, the high number of surveys in the study area shows relatively consistent results. There are also limitations in the detectability of marine mammals from aerial surveys. Appendix 12.1 seeks to address these limitations by estimating a correction factor in order to determine estimated absolute density estimates from the site specific aerial surveys.

92. Where possible, an overview of the confidence of the data and information underpinning the assessment will be presented. Confidence will be classed as High, Medium or Low depending on the type of data (quantitative, qualitative or lacking) as well as the source of information (e.g. peer reviewed publications, grey literature) and its applicability to the assessment.

12.6 Existing Environment

93. In UK waters, two groups of marine mammals occur: cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). The data presented by Reid *et al.* (2003), SCANS-I (Hammond *et al.,* 2002), SCANS-II (Hammond *et al.,* 2013), SCANS-III (Hammond *et al*., 2017) and JNCC (2013) indicate the marine mammal species that occur regularly over large parts of the southern North Sea are harbour porpoise, grey seal, harbour seal, white-beaked dolphin and minke whale.

94. Marine mammal species, including Atlantic white-sided dolphin, bottlenose dolphin, killer whale, sperm whale, long-finned pilot whale, Risso's dolphin, striped dolphin and other seal species are occasional or rare visitors to the southern North Sea (e.g. Reid *et al*., 2003; Hammond *et al.,* 2013, 2017; DECC, 2016; SCOS, 2017). Species

considered as occasional or rare visitors have not been considered further in the description of the existing environment for marine mammals.

95. The marine mammal species included in the assessment have been agreed with the marine mammal ETG (Table 12.4). Section 12.6.3 provides a summary of the relevant density estimates and reference populations that are used in the assessments.

12.6.1 Cetaceans

96. Cetacean populations occurring in UK waters are generally wide-ranging; their distribution and abundance vary considerably over time and space, influenced by both natural and anthropogenic factors (Reid *et al*., 2003). There may be areas of regular high density for some species, but how important these areas are in comparison to others in their natural range, is still generally unknown (Reid *et al*., 2003). Given that these species are not constrained to UK waters and are known to travel considerable distances, the assessment is made over a wider context to incorporate potential population impacts throughout their range.

97. Compared to the central and northern North Sea, the southern North Sea has a relatively low abundance of marine mammals, with the exception of the harbour porpoise (DECC, 2016). Ten species of cetacean have been recorded within the southern North Sea, however, only harbour porpoise can be considered to be common to the area throughout the year, with white-beaked dolphin and minke whale occurring as a seasonal visitors (DECC, 2016). Other dolphin species, such as bottlenose dolphin, common dolphin, Risso's dolphin and white-sided dolphin, are considered occasional (DECC, 2016).

98. The Joint Cetacean Protocol (JCP) data (Paxton *et al*., 2016) indicates that the only cetacean species recorded in the Norfolk Vanguard offshore project area is harbour porpoise, with no records of bottlenose dolphin, Risso's dolphin, minke whale, white-beaked dolphin, Atlantic white-sided dolphin or short-beaked common dolphin.

99. MARINElife (2017), a UK-based charity, record marine mammal and seabird sightings from a variety of platforms, including ferry routes crossing the southern North Sea area. Cetacean species recorded on the ferry routes from Hull to Zeebrugge in 2017 included one unidentified whale and two unidentified dolphins or porpoises in July 2017; one harbour porpoise in June 2017; and two bottlenose dolphins and three harbour porpoises off the Belgium coast for the log report in April 2017. The log reports from four trips between Hull to Zeebrugge in 2016 recorded one dolphin species in August 2016 and two harbour porpoise on two separate trips in May and

April 2016. During the Rosyth to Zeebrugge ferry trips in 2017 and 2016 the cetacean species recorded included harbour porpoise, white-beaked dolphin, minke whale, common dolphin and bottlenose dolphin. On the Felixstowe to Vlaardingen ferry route across the southern North Sea, harbour porpoise was the most recorded cetacean species in 2017 and 2016, the only other cetaceans recorded were four unidentified dolphin species in July 2016 and one unidentified dolphin in October 2016 and one minke whale in May 2016. It should be noted that from the sightings reports on the MARINElife (2017) website it is difficult to locate exactly where along the ferry routes the sightings were made and could be at any point between the two port locations.

100. Sea Watch volunteer cetacean sightings for the eastern England coast in 2017 and 2016 are predominantly harbour porpoise, the other cetacean species that have been recorded include common dolphins off Lincolnshire, Kings Lynn and Norfolk, bottlenose dolphin off Norfolk and Lincolnshire and white-beaked dolphin off Felixstowe and North Norfolk (Sea Watch Foundation, 2017).

101. The abundance of cetaceans across the former East Anglia Zone was modelled from the combined Enabling Action aerial survey data (2009-2010) and APEM aerial survey data as part of the Zone Environmental Appraisal (ZEA) Report (2010-2011). The results show low densities of cetaceans across the majority of the former Zone, including for the Norfolk Vanguard OWF sites. The pattern of densities seen from modelling suggests that there might be a correlation between water depth and density, with higher densities of cetaceans potentially relating to shallower areas of seafloor. This may be related to foraging activity around shallow sub-tidal sand banks (East Anglia Offshore Wind (EAOW), 2012a).

102. During the 2009-2011 surveys, as part of the ZEA, low numbers of cetaceans were recorded across the former Zone, with only 108 individual cetaceans identified from the 17 months of aerial data (EAOW, 2012a). The majority of the cetaceans positively identified in aerial surveys were harbour porpoise, which accounted for 38% of sightings, with an additional 53% listed as ‘small cetaceans’ (which are most likely to be harbour porpoise, but as identification could not be confirmed they are classed as small cetaceans). A further 6% of aerial sightings were identified as ‘patterned dolphins’ (which are most likely to be white-beaked dolphin) (EAOW, 2012a).

103. During 24 months of aerial surveys covering the East Anglia ONE site, to the south of Norfolk Vanguard, 181 cetaceans in total were recorded, 130 of which (72%) were positively identified as harbour porpoise, and a further 2.5% identified as either a porpoise or small cetacean (EAOW, 2012a).

104. The boat based survey data from the East Anglia ONE site identified 83% of all cetaceans recorded as being harbour porpoise. The boat based surveys also recorded low numbers of three dolphin species: white-beaked dolphin (8%), bottlenose dolphin (6%) and Risso's dolphin (2%), as well as unidentified dolphin species (2%). On the basis of the boat-based survey results, it was considered likely that the majority of 'small cetaceans' recorded from the Zone's aerial surveys were harbour porpoise.

105. During the 24 months (September 2011 to August 2013) of East Anglia THREE aerial surveys (adjacent to Norfolk Vanguard East with overlapping 4km buffers), 341 cetaceans in total were recorded within the site and buffer area, 149 of which (44%) were positively identified as harbour porpoise, and a further 188 (55%) identified as either a porpoise or small cetacean. Four white beaked dolphin were also recorded (East Anglia THREE Ltd (EATL), 2015).

106. During the NV East site surveys, including the East Anglia FOUR (EA4) surveys, from March 2012 to April 2016 for the OWF area and 4km buffer, 636 cetaceans were recorded, with 249 (39% of recorded sightings) identified as harbour porpoise and 373 (59% of recorded sightings) classed as unidentified small cetacean (which have been included as harbour porpoise for the impact assessment). Three white-beaked dolphin, two common dolphin, two patterned dolphin and seven unidentified dolphin species were also recorded (Appendix 12.1).

107. During NV West the site surveys from September 2015 to August 2017 for the OWF area and 4km buffer, 478 cetaceans were recorded, of which 144 (30% of recorded sightings) were identified as harbour porpoise and 317 (66% of recorded sightings) classed as unidentified small cetacean (which have been included as harbour porpoise for the impact assessment). Thirteen unidentified dolphin and four white-beaked dolphin were also recorded (Appendix 12.1).

108. The available data from the Norfolk Vanguard site specific survey, surveys within the former Zone, surveys for other offshore wind farms in the southern North Sea and other data sources, including SCANS-II (Hammond *et al*., 2013), SCANS-III (Hammond *et al*., 2017), indicate that harbour porpoise is the most abundant cetacean species present within this region, with occasional sightings of dolphin species (most likely white-beaked dolphin), with rare sightings of low numbers of other cetaceans.

109. As discussed previously, the main cetacean species included in the assessment is harbour porpoise. As agreed with the marine mammal ETG, consideration has been given to white-beaked dolphin and minke whale and baseline information has been included in section 12.6, however, given the low numbers and infrequent sightings of these species in and around Norfolk Vanguard, it has been concluded that there is a

very low risk of any significant impacts and therefore these species have not been assessed further.

12.6.1.1 Harbour porpoise

12.6.1.1.1 Distribution

110. Harbour porpoise is the most commonly sighted cetacean in the North Sea (Reid *et al*., 2003; WWT, 2009; ASCOBANS, 2012; Hammond *et al*., 2013, 2017; Sea Watch Foundation, 2017) and is the cetacean most likely to be observed in the Norfolk Vanguard site and offshore cable corridor.

111. Harbour porpoise distribution is generally restricted to the temperate and sub-arctic waters of the Northern Hemisphere, mainly on the continental shelf at depths of 20-200m and primarily within water temperatures ranging from 11 to 14^{o}C (DECC, 2016; Reid *et al*., 2003).

112. The JNCC Cetacean Atlas (Reid *et al*., 2003) recorded sightings of harbour porpoise throughout the southern North Sea, although the overall sightings were low in this region compared to the north and central North Sea (Reid *et al*., 2003).

113. Data on the distribution of marine mammals in UK areas of the North Sea have also been collected opportunistically during aerial surveys for birds conducted by WWT Consulting from 2001-2008 (WWT, 2009). Between 2001 and 2008, a total of 4,588 sightings, comprising 5,439 individual animals, were made of harbour porpoise (WWT, 2009). The results show a similar distribution in occurrence to those presented in Reid *et al*. (2003), with higher relative densities close to shore around the east coast and off the Lincolnshire and Yorkshire coasts, but with much higher relative densities recorded off the coast between Norfolk and Kent. Results for the WWT surveys are also similar to those recorded during SCANS-II, in which higher numbers of harbour porpoise were recorded in the southern North Sea areas than the more northerly survey areas.

114. A series of large scale surveys for cetaceans in European Atlantic waters was initiated in summer 1994 in the North Sea and adjacent waters (SCANS, 1995; Hammond *et al*., 2002) and continued in summer 2005 in all shelf waters (SCANS-II, 2008; Hammond *et al*., 2013). Despite no overall change in population size between the SCANS-I and SCANS-II surveys, large scale changes in the distribution of harbour porpoise were observed between 1994 and 2005, with the main concentration shifting from North eastern UK and Denmark to the southern North Sea. Such large scale changes in the distribution of harbour porpoise are likely the result of changes to the availability of principal prey within the North Sea (SCANS-II, 2008).

115. Initial data from the SCANS-III survey also indicates that the occurrence of harbour porpoise is greater in the central and southern areas of the North Sea compared to the northern North Sea (Plate 12.1; Hammond *et al*., 2017), which is consistent with SCANS-II. Modelling of the new data from 2016 to investigate fine scale distribution and habitat use is in progress (Hammond *et al*., 2017).

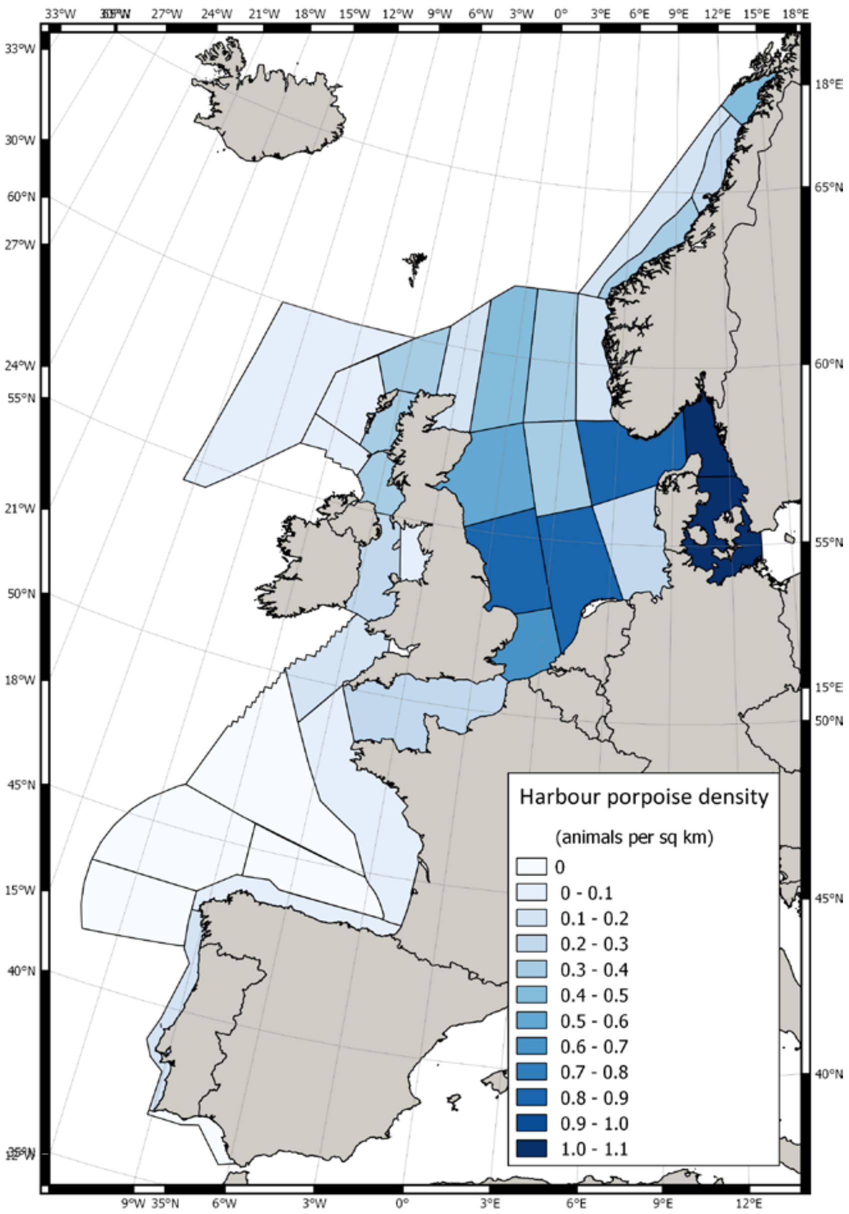

Plate 12.1 Estimated density of harbour porpoise in each SCANS-III survey block (Source: Hammond *et al*., 2017)

116. Statistical modelling of 18 years of survey data between 1994 and 2011 of the entire UK Exclusive Economic Zone (EEZ) for harbour porpoise using the JCP data together with environmental data (such as water depth, hydrodynamics, sediments and shipping) was undertaken by Heinänen and Skov (2015) to identify discrete and

persistent areas of relatively high harbour porpoise density. The model results (Heinänen and Skov, 2015) indicated that the sampled densities of harbour porpoises were influenced by both oceanographic and anthropogenic pressure variables. The coarseness of surface sediments played a major role in the presence and density of porpoises. Water depth and hydrodynamic variables also had an influence on harbour porpoise distribution in the North Sea, with peaks in preferences during summer at depths of 40m and 200m. Other variables included surface salinity, stability of the water column (described by temperature differences), stratification and eddy activity. The model results also indicated a negative relationship between the number of ships and the distribution of harbour porpoises in the North Sea (Heinänen and Skov, 2015).

117. Within the southern North Sea, Heinänen and Skov (2015) identified one area of high harbour porpoise density; from the western slopes of Dogger Bank south along a 30m depth contour towards an area off the Norfolk coast. This was further split into three areas due to inter-annual variations:

- North-western edge of Dogger Bank (summer);
- Inner Silver Pit; and
- Offshore area east of Norfolk and east of outer Thames estuary (winter).

118. The Heinänen and Skov (2015) analysis was used in the identification of potential SACs for harbour porpoise in UK waters (see section 12.6.1.4).

119. Gilles *et al*. (2016) assessed nine years of harbour porpoise survey data (2005 to 2013) collected in the UK (SCANS II, Dogger Bank), Belgium, the Netherlands, Germany, and Denmark, to develop seasonal habitat-based density models for the central and southern North Sea. The models indicated that densities generally increased with day length, with highest densities predicted when day length exceeded 14.5 hours during the months of June through August. The highest harbour porpoise density occurred 150km offshore and at depths between 25 and 40m. Harbour porpoise densities also increased with higher probability for sea surface temperature (SST) fronts and decreased with distance to sandeel grounds.

120. The seasonal maps produced by Gilles *et al*. (2016) for harbour porpoise density across the central and south-eastern North Sea were consistent with previously described seasonal patterns of harbour porpoise distribution. The spring seasonal density map indicated major hotspots in the southern and south-eastern part of the North Sea, mainly inshore close to the Belgian and Dutch coasts extending toward the German coast off the East Frisian Islands. The model also predicted high densities in the area of the Sylt Outer Reef in the German North Sea as well as north off the coast of Jutland in Denmark. Another potential hotspot in spring was at

Dogger Bank and the area north-west of this large sandbank (Gilles *et al.,* 2016). In summer, there was an apparent shift, compared to spring, toward offshore and western areas, with a large hotspot present off the German and Danish west coast that extended toward the Dogger Bank. The seasonal model for autumn indicated lower densities compared to spring and summer, the distribution was spatially heterogeneous and areas with higher densities were predicted north-west of the Dogger Bank and off the German and Danish west coasts (Gilles *et al*., 2016).

121. The JCP Phase-III report (Paxton *et al*., 2016) indicated that for the Norfolk Bank development area (an area comprising the former East Anglia Zone), abundances of harbour porpoise ranged from 5,300 (CI = 2,600-15,600) in the spring and 13,700 (CI = 7,000-26,200) in the winter, with numbers in summer and autumn being in between this range. The Norfolk Bank development area covers 2.4% of the North Sea MU, but the abundance estimate of harbour porpoise in this area equates to 13.9% (CI = 8.9-19.2%) of the North Sea MU, indicating a high use of the area (Paxton *et al*., 2016). Plate 12.2 illustrates the distribution of harbour porpoise, based on modelled densities for summer 2010 from the JCP Phase-III report.

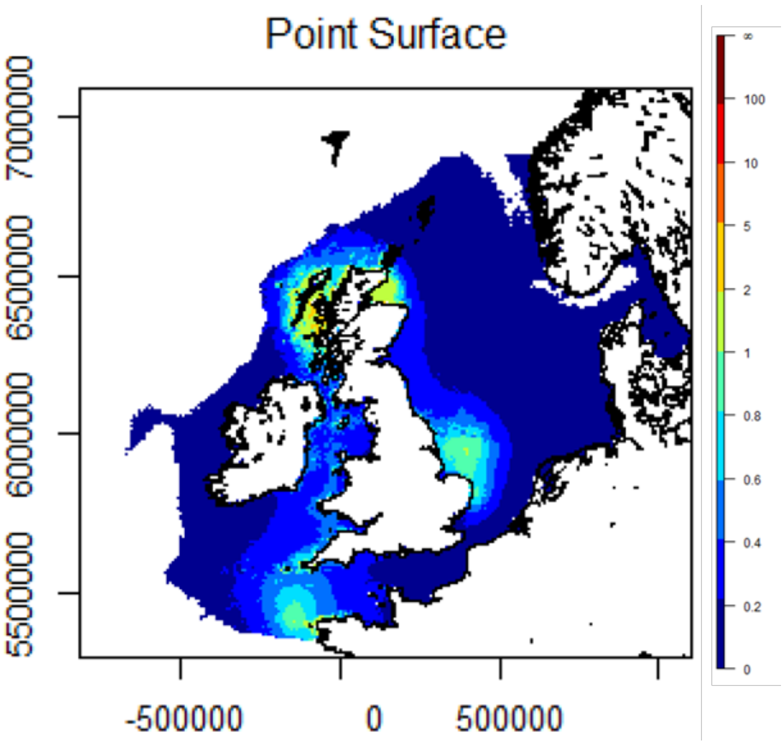

Plate 12.2 Distribution of harbour porpoise based on predicted JCP harbour porpoise densities (animals/km^2) for summer 2010 (Source: Paxton *et al.*, 2016).

12.6.1.1.2 Diet

122. The distribution and occurrence of harbour porpoise and other marine mammals is most likely to be related the availability and distribution of their prey species. For

example, sandeels (Ammodytidae), which are known prey for harbour porpoise, exhibit a strong association with particular surface sediments (Gilles *et al*., 2016; Clark *et al.*, 1998).

123. Harbour porpoises are generalists and their diet will therefore differ according upon their location. The diet varies geographically, seasonally and annually, reflecting changes in available food resources and differences in diet between sexes or age classes may also exist (Berrow and Rogan, 1995; Kastelein *et al*., 1997; Börjesson *et al*. 2003; Santos and Pierce, 2003; Santos *et al*., 2004; Pierce *et al.*, 2007).

124. The diet of the harbour porpoise consists of a wide variety of fish, including pelagic schooling fish, as well as demersal and benthic species, especially Gadoids, Clupeids and Ammodytes. Other prey species such as cephalopods, other molluscs, crustaceans and polychaetes have also been recorded. The main prey fish species of harbour porpoise typically include sandeels (Ammodytidae spp.), whiting *Merlangius merlangus*, herring *Clupea harengus*, mackerel *Scomber scombrus*, sprat *Sprattus sprattus*, cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, saithe *Pollachius virens*, pollack *Pollachius pollachius*, Norway pout *Trisopterus esmarkii* as well as flat fish such as flounder *Platichthys flesus* and sole *Solea solea* (Rogan and Berrow, 1996; Reid *et al*., 2003; Santos and Pierce, 2003; Santos *et al*., 2004; Evans and Baines, 2010).

125. Harbour porpoise tend to concentrate their movements in small focal regions (Johnston *et al*., 2005), which often approximate to particular topographic and oceanographic features and are associated with prey aggregations (Raum-Suryan and Harvey, 1998; Johnston *et al*., 2005; Keiper *et al*., 2005; Tynan *et al*., 2005). Consequently, habitat use is highly correlated with prey density rather than any particular habitat type.

126. Harbour porpoise have relatively high daily energy demands and need to consume between 4% and 9.5% of their body weight in food per day (Kastelein *et al*., 1997). If a harbour porpoise does not capture enough prey to meet its daily energy requirements it has been estimated that it can only rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al*., 1997).

127. A recent study by Wisniewska *et al*. (2016) using high-resolution movement and prey echo recording tags on five wild harbour porpoise has shown that porpoises forage nearly continuously day and night, to meet their metabolic demands foraging on small prey. Although harbour porpoise diet typically comprises of large numbers of relatively small fish prey, primarily <25 cm and frequently <5 cm in length (e.g. Börjesson *et al*., 2003) as outlined above, they feed on wide variety of prey species and sizes, and would be expected to take larger prey when available. However,

larger prey sizes overlap with those taken by commercial fisheries (Wisniewska *et al*., 2016).

12.6.1.1.3 Abundance and density estimates

North Sea MU

128. Harbour porpoise within the eastern North Atlantic are generally considered to be part of a continuous biological population that extends from the French coastline of the Bay of Biscay to northern Norway and Iceland (Tolley and Rosel, 2006; Fontaine *et al*., 2007, 2014; IAMMWG, 2015). However, for conservation and management purposes, it is necessary to consider this population as smaller MUs. MUs provide an indication of the spatial scales at which effects of plans and projects alone, and in-combination, need to be assessed for the key cetacean species in UK waters, with consistency across the UK (IAMMWG, 2015).

129. The IAMMWG defined three MUs for harbour porpoise: North Sea; West Scotland (WS); and the Celtic and Irish Sea (CIS). Norfolk Vanguard is located in the North Sea MU. The North Sea MU comprises ICES area IV, VIId and part of Division IIIa (Skagerrak and northern Kattegat (Plate 12.3). IAMMWG (2015) note that the northern and western boundary with Division VIa is arbitrary (but the shelf is relatively narrow here) and that there will be an interchange of animals here with the 'West Scotland' MU. The eastern boundary has been defined by the ASCOBANS North Sea Conservation Plan for the species.

130. The SCANS-III estimate of harbour porpoise abundance in the North Sea MU was 345,373 (CV = 0.18; 95% CI = 246,526-495,752) with a density estimate of 0.52/km2 (CV = 0.18; Hammond *et al*., 2017). This is the reference population for harbour porpoise, as agreed with Natural England as part of the EPP (letter dated 03/01/2018; Table 12.4).

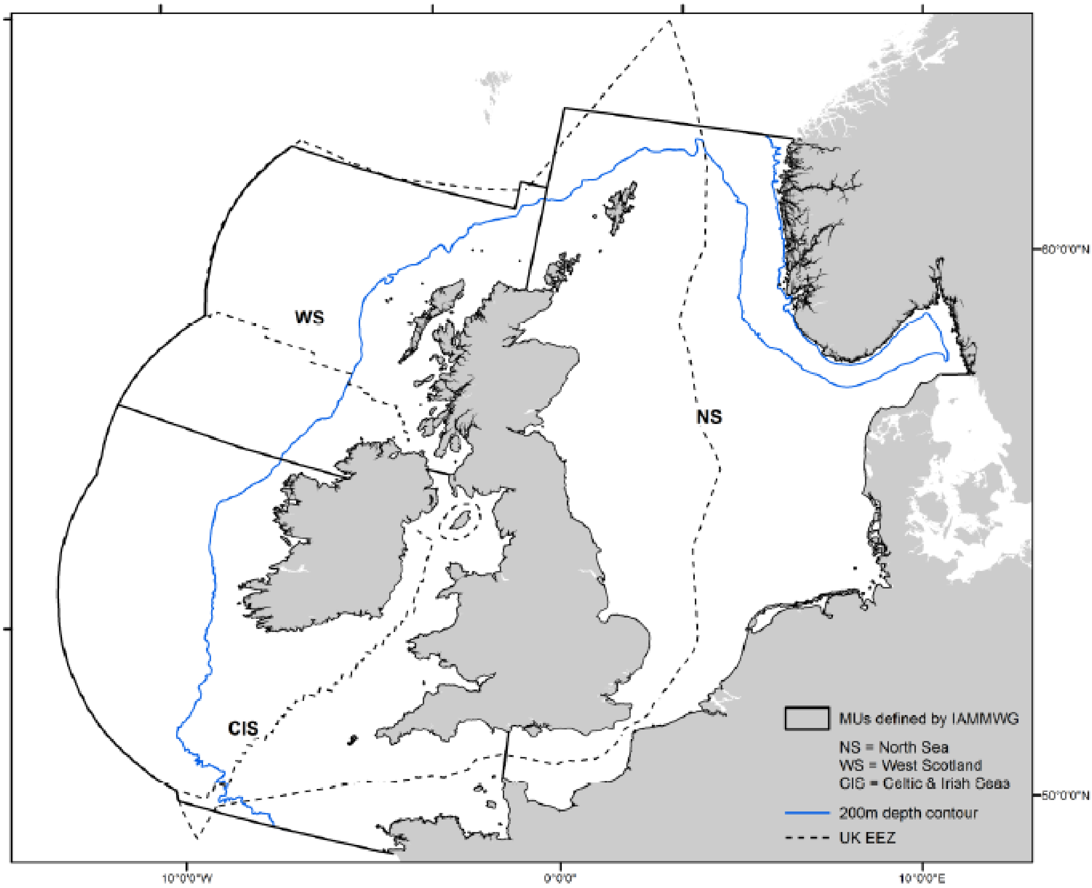

Plate 12.3 Harbour porpoise MUs (Source: IAMMWG, 2015)

SCANS data

131. In July 2005, SCANS-II surveyed the entire EU Atlantic continental shelf to generate robust estimates of abundance for harbour porpoise and other cetacean species. For the entire SCANS-II survey area, harbour porpoise abundance in the summer of 2005 was estimated to be 375,358 (CV = 0.197; Hammond *et al*., 2013). The SCANS-II survey estimated that the abundance of harbour porpoise in survey block B (Plate 12.4), which encompasses Norfolk Vanguard, was 40,927 (CV=0.38) with an estimated mean density of 0.331 individuals per km^2 (CV 0.38; Hammond *et al*., 2013).

132. SCANS-III in the summer of 2016 surveyed all European Atlantic waters from the Strait of Gibraltar in the south to 62°N in the north and extending west to the 200nm limits of all EU Member States (Plate 12.5**;** Hammond *et al*., 2017). The survey area was not the same as SCANS-II. For the entire SCANS-III survey area, harbour porpoise abundance in the summer of 2016 was estimated to be 466,569 with an overall estimated density of 0.381/km^2 (CV = 0.154; 95% CI = 345,306-630,417; Hammond *et al*., 2017).

133. NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O (Plate 12.5).

- The estimated abundance of harbour porpoise in SCANS-III survey block L is 19,064 harbour porpoise (CV=0.38; 95% CI = 6,933-35,703), with an estimated density of 0.607 harbour porpoise/km^2 (CV=0.38; Hammond *et al*., 2017).
- The estimated abundance of harbour porpoise in SCANS-III survey block O is 53,485 harbour porpoise (CV=0.21; 95% CI = 37,413-81,695), with an estimated density of 0.888 harbour porpoise/km^2 (CV=0.21; Hammond *et al*., 2017).

134. It should be noted that SCANS data is corrected for any animals that might be missed and therefore the application of any further correction factors is not required. For the SCANS aerial surveys, data was collected from which correction could be made for animals missed on the transect line, by using the circle-back or "racetrack" method. In this approach, on detecting a group of animals, the aircraft circles back to resurvey a defined segment of transect. The method used on ships was a double platform line transect survey with two independent teams of observers on each ship to generate data that would allow abundance estimates to be corrected for animals missed on the transect line and also potentially for the effects of movement of animals in response to the ship (Hammond *et al*., 2017).

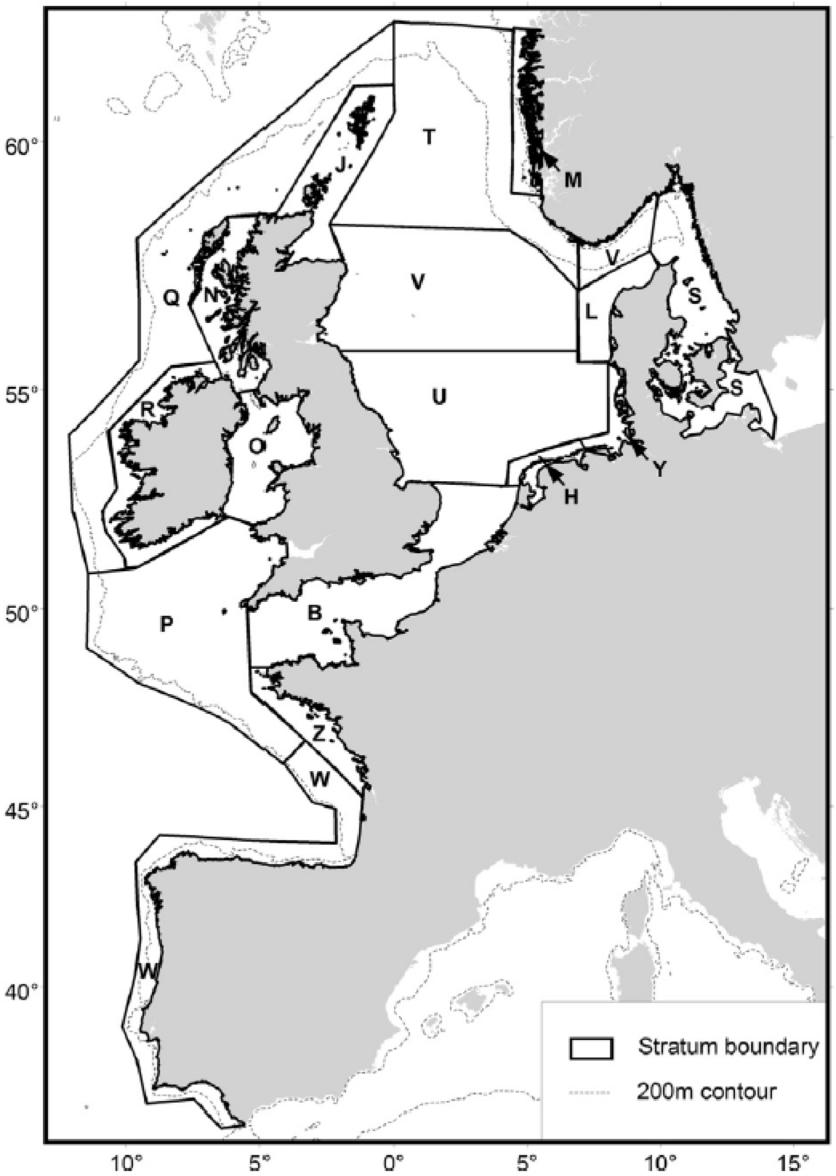

Plate 12.4 Survey blocks for the SCANS-II surveys (Source: Hammond *et al*., 2013)

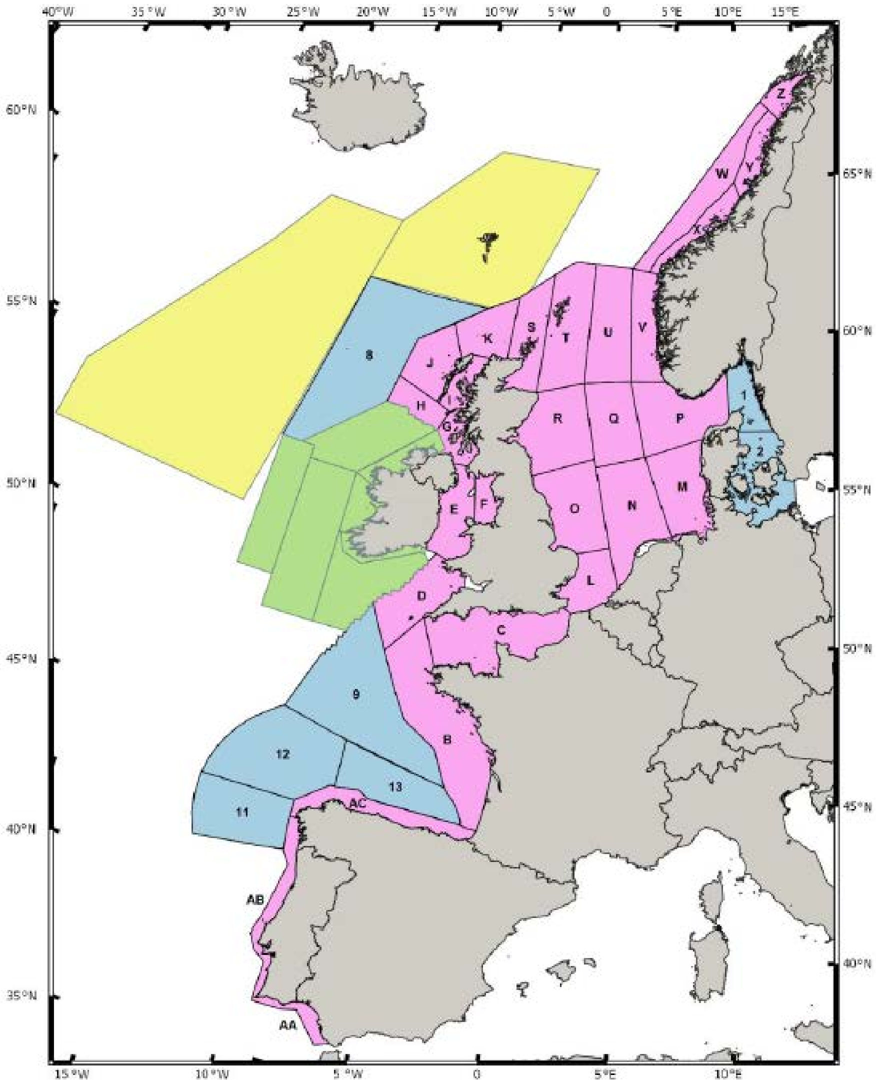

Plate 12.5 Survey blocks covered by SCANS-III and adjacent surveys (Source: Hammond *et al.*, 2017). SCANS-III = pink lettered blocks surveyed by air; blue numbered blocks were surveyed by ship. Blocks coloured green to the south, west and north of Ireland were surveyed by the Irish ObSERVE project. Blocks coloured yellow were surveyed by the Faroe Islands as part of the North Atlantic Sightings Survey in 2015.

East Anglia Zone surveys

135. As outlined in section 12.6.1, the majority of sightings during the 2009-2011 surveys for the ZEA, were harbour porpoise (38%) and a further 53% were recorded as 'small cetaceans' (which were most likely to be harbour porpoise; EAOW, 2012c).

136. For the East Anglia ONE OWF, further marine mammal aerial surveys were conducted within the former Zone. During the 24 months of aerial surveys, 130 of the 181 cetacean sightings (72%) were positively identified as harbour porpoise, 12.5% identified as either a porpoise or dolphin (which were most likely to be harbour porpoise), 0.5% as a patterned dolphin, and a further 15% were recorded as

unidentified cetacean species (EAOW, 2012b). The boat based survey data from East Anglia ONE identified 83% of all cetacean sightings as harbour porpoise (EAOW, 2012b).

137. Aerial surveys were conducted for the East Anglia THREE site plus a 4km buffer between September 2011 and August 2013. The East Anglia THREE aerial surveys indicated harbour porpoise occurred across the East Anglia THREE site plus buffer during both survey years. During the East Anglia THREE aerial surveys high resolution aerial stills capture marine mammals both above and just below the surface. The mean estimates of density were generated from the East Anglia THREE site plus buffer using counts with a correction factor (based on the Joint Cetacean Protocol Phase II report (Paxton *et al.*, 2011)) to take into account animals that were not seen (EATL, 2015). The estimated mean density of harbour porpoise within the East Anglia THREE site plus buffer across the full 24 month survey period was 0.179 individuals per km^2 and for all sightings classified as 'unidentified small cetacean' that were assumed to be harbour porpoise the estimated density was 0.294 individuals per km^2 (EATL, 2015).

Norfolk Vanguard site specific surveys

138. As outlined in section 12.5.2, APEM collected high resolution aerial digital still imagery for marine mammals over NV East (and the former East Anglia FOUR) and NV West, with a 4km buffer area, covering a total of $645km^2$. The monthly surveys collected imagery data at 2cm Ground Sampling Distance (GSD) on a 500m by 400m irregular grid-based survey to achieve a minimum of 10% coverage in each survey period (each month). Coverage of the Norfolk Vanguard OWF sites and 4km buffer was between approximately 12% and 13% per month. Plate 12.1 in Appendix 12.1 shows the survey areas for the Norfolk Vanguard OWF sites. Further information is provided on the analysis and interpretation of the survey results in Appendix 12.1.

139. The information included in the ES is based on 32 months of survey for NV East (East Anglia Four (EA4) surveys (March 2012 – February 2014) and the NV East surveys (September 2015 – April 2016)) and 24 months site specific survey data for NV West (September 2015 – August 2017).

140. All images were analysed to enumerate marine mammals to species level, where possible. APEM undertook internal quality assurance to check for missed animals and to ensure the correct species were identified, followed by external QA by the Sea Mammal Research Unit (SMRU).

141. Data from the site specific surveys were used to generate density estimates for NV East and NV West. Information on the data analysis is provided in Appendix 12.1.

142. Density estimates were calculated from the raw data counts (provided in Appendix 12.1) for harbour porpoise species and unidentified small cetacean. Correction factors (see below) were then applied to the data to account for the presence of individuals below 2m water depth (the depth at which it is no longer possible to detect marine mammals from aerial imagery).

Species identification

143. In some instances, images had sufficient clarity to identify an individual to species level, whereas for other individuals the clarity may not have been sufficient to identify to species levels and it was necessary to categorise the individual at a lower identification level e.g. unidentified dolphin species.

144. To date, surveys within the Norfolk Vanguard OWF sites indicate that harbour porpoise are the most abundant marine mammal species. It is therefore assumed that many unidentified small cetaceans are likely to be harbour porpoise. As a worst-case scenario, the maximum possible density estimate for harbour porpoise has been obtained by adding the number of harbour porpoise recorded to the number of unidentified small cetaceans.

Correction factors

145. It is only possible for aerial imagery to capture marine mammals at the sea surface and just below, therefore correction factors must be applied to the raw data counts for each species to account for individuals that could be below the sea surface.

146. As outlined in Appendix 12.1, Voet *et al*. (2017) determine seasonal correction factors for harbour porpoise that can be used to determine density estimates obtained from aerial digital surveys (Table 12.11), based on published dive profile data from harbour porpoise tagged in the North Sea (see Appendix 12.1 for further details).

147. The Teilmann *et al*. (2013) tagging study indicated significant differences in the percentage of time that each harbour porpoise spent between 0 and 2m water depth depending on the time of year. Spring and summer had a higher average time spent between 0 and 2m compared to autumn and winter. Therefore, to take this into account, Teilmann *et al*. (2013) suggest that aerial survey data should be corrected for time submerged as well as for seasonal effects (Table 12.11).

Table 12.11 Harbour porpoise seasonal correction factors

Season	Correction Factor
Spring (Mar – May)	0.571
Summer (Jun – Aug)	0.547
Autumn (Sept – Nov)	0.455
Winter (Dec - Feb)	0.472

148. The seasonal correction factors in Table 12.11 were applied to the monthly data to take into account the probability of harbour porpoise being below the water surface or detection zone (i.e. below 2m for harbour porpoise) and being undetectable by aerial surveys.

149. Turbidity can affect the ability to detect marine mammals in the 2m detection zone below the surface. However, as outlined in Chapter 8 Marine Geology, Oceanography and Physical Processes and Chapter 9 Marine Water Quality and Sediment Quality, measurements of suspended sediment concentrations were carried out at the Acoustic Wave and Current (AWAC) station in NV East between December 2012 and December 2013. Overall, suspended sediment concentrations were between 0.3 and 108mg/l throughout the survey period. Concentrations were less than 30mg/l for 95% of the time and less than 10mg/l for 70% of the time.

150. Water clarity (Secchi depth) in the North Sea varies with water depth and distance from the coast (Dupont and Aksnes, 2013). Long-term overall measurements of Secchi depth for the southern and central North Sea in the area of Norfolk Vanguard indicate means of between 5.52m^{-1} (SD = 1.06) and 3.27m^{-1} (SD=2.22) in summer, 2.70m^{-1} (SD = 2.41) in spring / autumn and 1.66m^{-1} (SD = 0.93) in winter (Capuzzo *et al*., 2015).

151. Therefore, there is no indication of any limitations in observing marine mammals up to 2m below the surface. The correction factors take into account the number of animals that could be below 2m from the surface and not detected during the aerial surveys.

152. Correction factors are based on individual species and typically cannot be applied to species groups (such as unidentified small cetaceans). However, as it is assumed that all individuals in the ‘harbour porpoise and unidentified small cetacean’ group are harbour porpoise, the correction factor for harbour porpoise has been applied to this group.

153. As outlined in Appendix 12.1, previously the acceptance of digital survey methods has been queried owing to uncertainty over their ability to provide reliable estimates of spatial and temporal variation in absolute abundance or density as corrected from relative measures. However, correcting the density estimates for availability bias increases the confidence levels in these estimates. Therefore, it is believed that the harbour porpoise aerial digital counts corrected using the seasonal correction factors (Table 12.11) deliver realistic density estimates.

154. The density estimates from the site specific aerial surveys using the correction factors are comparable to those from the SCANS-III survey, although as expected are

slightly higher for the site specific survey areas compared to the larger SCANS-III survey blocks. For example, the SCANS-III density estimate for survey block O (0.888 harbour porpoise per km^2) is within the range of the NV East and NV West density estimates (Table 12.21).

Density estimates

155. At NV East (without buffer as this provides the worst-case scenario), when unidentified small cetaceans are included with the harbour porpoise data (Table 12.12), the highest density estimate was in February 2016, with an uncorrected density estimate of 1.73/km^2 (CI = 1.16-2.32). The corrected density estimates when using the seasonal correction factor is 3.65/km^2 for the OWF site (without buffer). However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the February estimate (Table 12.12).

156. The annual mean density estimate, when using the seasonal correction factor is 1.26/km^2 for NV East (without buffer; Table 12.12).

157. The density estimate during summer (April to September) is 0.73/km^2 and during the winter (October to March) the estimated density is 1.8/km^2 at NV East.

Table 12.12 The highest monthly density estimates for Norfolk Vanguard East for harbour porpoise and unidentified small cetaceans with and without seasonal correction factors

By Month	Density Estimate (individuals / km^2) based on raw data (CI)	Density Estimate (individuals / km^2) with seasonal correction factor
Jan	1.06 (0.55-1.61)	2.25
Feb	1.73 (1.16-2.32)	3.65
Mar	0.79 (0.50-1.35)	1.38
Apr	0.27 (0.11-0.56)	0.48
May	0.45 (0.15-0.97)	0.79
Jun	0.19 (0.02-0.37)	0.59
Jul	0.22 (0.04-0.46)	0.69
Aug	0.24 (0.09-0.42)	0.74
Sep	0.49 (0.29-0.80)	1.07
Oct	0.21 (0.08-0.36)	0.46
Nov	0.60 (0.31-0.91)	1.31
Dec	0.83 (0.35-1.34)	1.75
Annual	0.59 (0.31-0.96)	**1.26**

158. At NV West (without buffer as this represents the worst-case scenario), when unidentified small cetaceans are included with the harbour porpoise data (Table 12.13), the highest density estimate was in September 2015, with an uncorrected

density estimate of 1.04/km^2 (CI = 0.61-1.29). The corrected density estimate using the seasonal correction factor is 2.29/km^2 for NV West (without buffer). However, the other monthly density estimates for harbour porpoise, including unidentified small cetaceans, are considerably lower than the September estimate (Table 12.13).

159. The annual mean density estimate, when using the seasonal correction factor is 0.79/km^2 for the NV West area (without buffer).

160. The density estimate during summer (April to September) is 0.57/km^2 and during the winter (October to March) the estimated density is 1.01/km^2 at NV West.

Table 12.13 The highest monthly density estimates for Norfolk Vanguard West for harbour porpoise and unidentified small cetacean or porpoise with and without seasonal correction factors

By Month	Density Estimate (individuals / km^2) based on raw data (CI)	Density Estimate (individuals / km^2) with seasonal correction factor
Jan	0.85 (0.55-1.18)	1.80
Feb	0.62 (0.28-1.02)	1.31
Mar	0.12 (0.00-0.31)	0.22
Apr	0.28 (0.06-0.56)	0.49
May	0.06 (0.00-0.14)	0.11
Jun	0.00 (0.00-0.00)	0.00
Jul	0.03 (0.00-0.10)	0.06
Aug	0.25 (0.11-0.40)	0.45
Sep	1.04 (0.61-1.29)	2.29
Oct	0.18 (0.06-0.33)	0.39
Nov	0.76 (0.38-1.20)	1.67
Dec	0.33 (0.18-0.47)	0.69
Annual	0.38 (0.19-0.59)	**0.79**

161. The NV East and NV West density estimates of 1.26/km^2 and 0.79/km^2, respectively, based on the mean annual density and using the seasonal correction factors have been used in the assessment (Table 12.21). Using the mean annual density allows for seasonal variation in the number of harbour porpoise that could be present. However, it should be noted that the majority of the offshore construction work would occur during summer months when the density estimates are lower, therefore using the annual density estimates is considered a precautionary approach.

12.6.1.1.4 Reference population for assessment

162. The reference population used in the assessment for harbour porpoise is the latest SCANS-III estimate of harbour porpoise abundance in the North Sea MU of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond *et al*., 2017).

12.6.1.2 Dolphin species

12.6.1.2.1 Distribution

163. White-beaked dolphin are widespread across the northern European continental shelf and in the North Sea they tend to be more numerous within 200nm of the Scottish and north-eastern English coasts (Northridge *et al*., 1995). White-beaked dolphin are present year-round in the North Sea, mainly in waters of 50-100m depth, with most sightings recorded between June and October (Reid *et al*., 2003). This species is cited as the most abundant cetacean after harbour porpoise in the North Sea (Jansen *et al.,* 2010), and the waters off the coast of Scotland and north east England are one of the four global areas of peak abundance. White-beaked dolphin are widely distributed within the central North Sea, however, very few sightings are recorded along the east coast of England or south of the Humber Estuary, with a small number of sightings in offshore waters within the shallow waters near the North Norfolk Sandbanks and Dogger Bank areas (Gilles *et al*., 2012; DECC, 2016). The occurrence of white-beaked dolphin in the southern North Sea is relatively low (Reid *et al*., 2003; Hammond *et al*., 2013, 2017).

164. The bottlenose dolphin has a worldwide distribution across tropical and temperate seas of both hemispheres and can be found in coastal and continental shelf waters (Reid *et al*., 2003; DECC, 2016). In most regions, including the UKCS, inshore and offshore 'sub-populations' tend to be distinct (DECC, 2016; Oudejans *et al*., 2015). In UK waters, inshore individuals are frequently reported off north-east and south-west Scotland, in the Irish Sea, and in the western English Channel (DECC, 2016; IAMMWG, 2015). There are two main areas of UK territorial waters where there are semi-resident groups of bottlenose dolphins: Cardigan Bay in Wales and the Moray Firth on the north-east coast of Scotland, both of these areas have been designated SACs for bottlenose dolphins. There are also smaller populations of bottlenose dolphins off south Dorset and around Cornwall (Williams *et al*. 1996; Wood 1998). The occurrence of bottlenose dolphin in the southern North Sea is very low (Reid *et al*., 2003; Hammond *et al*., 2013, 2017).

165. The common dolphin is the most numerous offshore cetacean species in the north east Atlantic, most often sighted off the western coast of the UK, in the Celtic Sea, and western approaches to the Channel, it is only occasionally sighted in the North Sea during the summer months (Reid *et al*., 2003).

166. As outlined in section 12.6.1, during the Rosyth to Zeebrugge ferry trips in 2017 and 2016 the cetacean species recorded included white-beaked dolphin in May 2017; common dolphin in February 2017, August 2016, March 2016 and February 2016; and bottlenose dolphin April 2016 (MARINElife, 2017). On the Hull to Zeebrugge

ferry route, bottlenose dolphin were recorded off the Belgium coast in April 2017 and one unidentified dolphin species in August 2016. On the Felixstowe to Vlaardingen ferry route across the southern North Sea, four unidentified dolphin species were recorded in July 2016 and one unidentified dolphin in October 2016 (MARINElife, 2017). It should be noted, that these sightings could have been made at any point between the two port locations.

167. Sea Watch volunteer cetacean sightings for eastern England coast in 2017 and 2016 include common dolphins off Lincolnshire, Kings Lynn and Norfolk, bottlenose dolphin off Norfolk and Lincolnshire and white-beaked dolphin off Felixstowe and North Norfolk (Sea Watch Foundation, 2017).

12.6.1.2.2 Abundance and density estimates

Management units

168. Scientific evidence supports the assumption that white-beaked dolphin from around the British Isles and North Sea represent one population, with movement between Scottish waters and the Danish North Sea and Skagerrak (Banhuera-Hinestroza *et al.,* 2009; IAMMWG, 2015). The single MU for white-beaked dolphin, the Celtic and Greater North Seas (CGNS) MU, comprises all UK waters and extends to the seaward boundary used by the European Commission for Habitats Directive reporting (area known as Marine Atlantic, termed MATL) (IAMMWG, 2015). However, it is worth noting that this species usually occurs on the continental shelf (Reid *et al.,* 2003; IAMMWG, 2015). The abundance of white-beaked dolphin in the CGNS MU is 15,895 animals (CV=0.29; 95% CI=9,107-27,743; IAMMWG, 2015) and in the UK EEZ white-beaked dolphin abundance is 11,694 (CV = 0.30; 95% CI = 6,578-20,790), which are derived from the SCANS-II abundance estimate for continental shelf waters (Hammond *et al.,* 2013).

169. IAMMWG currently recognise seven MUs for bottlenose dolphin in UK waters. The Norfolk Vanguard offshore project area is located in the Greater North Sea (GNS) MU, which is represented by ICES Area IV, excluding coastal east Scotland; and ICES area IIIa. The estimated bottlenose dolphin population size of the GNS MU is zero (IAMMWG, 2015).

170. The single MU for common dolphin, the CGNS MU, comprises all UK waters and extends to the seaward boundary (IAMMWG, 2015). The abundance of common dolphin in the CGNS MU is 56,556 (CV = 0.28; 95% CI = 33,014-96,920) and the UK component (abundance within the UK EEZ) is 13,607 (CV = 0.23; 95% CI = 8,720-21,234). These estimates were derived from SCANS-II (Hammond *et al*., 2013) and Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA;

Macleod *et al*., 2009) and are likely to be biased low due to perception bias that could not be corrected for in the aerial surveys (IAMMWG, 2015).

SCANS data

171. The SCANS-II survey provided a wider European population estimate of 16,536 white-beaked dolphin (95% CI = 9,245 – 29,586; Hammond *et al.,* 2013). No white-beaked dolphin were recorded for the SCANS-II survey block B, in which the Norfolk Vanguard offshore project area is located (Hammond *et al*., 2013).

172. For the entire SCANS-III survey area (not the same area as SCANS-II), white-beaked dolphin abundance in the summer of 2016 was estimated to be 36,287 with an overall estimated density of 0.020/km^2 (CV = 0.290; 95% CI = 18,694-61,869; Hammond *et al*., 2017). As previously discussed, NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O. White-beaked dolphin were not recorded in survey block L during SCANS-III survey. The estimated abundance in SCANS-III survey block O was 143 white-beaked dolphins (CV=0.97; 95% CI = 0-490), with an estimated density of 0.002 white-beaked dolphins per km^2 (CV=0.97; Hammond *et al*., 2017).

173. During the SCANS-II surveys, two bottlenose dolphin groups were sighted within survey block B, in which the Norfolk Vanguard offshore project area is located, resulting in an estimated density of 0.0032 individuals per km^2 (CV = 0.74) and an abundance estimate of 395 bottlenose dolphin (CV = 0.74; Hammond *et al*., 2013). During the SCANS-III surveys no bottlenose dolphin were recorded in survey block O or survey block L (Hammond *et al*., 2017).

174. Common dolphin were not recorded in the North Sea area during the SCANS-II or SCANS-III surveys (Hammond *et al*., 2013; 2017).

East Anglia Zone surveys

175. Surveys undertaken in the former Zone from November 2009 until April 2011 recorded very low numbers of patterned dolphins (6% of the 108 cetacean sightings), which were most likely to be white-beaked dolphin (EAOW, 2012c).

176. The boat based surveys for East Anglia ONE recorded low numbers of three dolphin species: white-beaked dolphin (8% of 181 cetacean sightings), bottlenose dolphin (6% of 181 cetacean sightings) and Risso's dolphin (2% of 181 cetacean sightings), as well as unidentified dolphin species (2% of cetacean sightings; EAOW, 2012b).

177. During 24 months of aerial surveys conducted for the East Anglia THREE site plus buffer, four white-beaked dolphin were recorded (for the dolphins which could be identified to species level). These sightings lead to very low estimates of average abundance and density across the site, and given the sporadic nature of the sightings

it was not appropriate to assume an average density over the entire survey period (EATL, 2015). No bottlenose dolphin were positively sighted during the aerial surveys of the East Anglia THREE site plus buffer (EATL, 2015). Only one common dolphin was recorded across the 24 month site specific survey period, in December 2011 within the East Anglia THREE site plus buffer (EATL, 2015).

Norfolk Vanguard site specific surveys

178. The total number of dolphin species recorded during the aerial surveys for NV East, including the EA4 surveys, from March 2012 to April 2016 (32 months) was 14 dolphins for NV East and 4km buffer. Of these, only three were identified as white-beaked dolphin, two as patterned dolphin, two as common dolphin and seven as unidentified dolphin species (Table 12.14).

Table 12.14 Dolphin species recorded during aerial surveys of NV East, including EA4 surveys, undertaken between March 2012 and April 2016 for the OWF site and 4km buffer

Date	Common dolphin	White-beaked dolphin	Patterned dolphin sp.	Dolphin species
March 2012	0	0	0	0
April 2012	0	0	0	2
May 2012	0	1	0	1
June 2012	0	0	0	1
July 2012	2	0	0	0
August 2012	0	0	0	1
September 2012	0	0	0	0
October 2012	0	0	0	0
November 2012	0	0	0	1
December 2012	0	0	0	0
January 2013	0	0	0	1
February 2013	0	0	2	0
March 2013	0	0	0	0
April 2013	0	0	0	0
May 2013	0	0	0	0
June 2013	0	0	0	0
July 2013	0	0	0	0
August 2013	0	0	0	0
September 2013	0	0	0	0
October 2013	0	0	0	0
November 2013	0	0	0	0
December 2013	0	0	0	0
January 2014	0	0	0	0
February 2014	0	0	0	0
September 2015	0	0	0	0
October 2015	0	0	0	0
November 2015	0	0	0	0
December 2015	0	0	0	0
January 2016	0	0	0	0
February 2016	0	2	0	0
March 2016	0	0	0	0
April 2016	0	0	0	0

Date	Common dolphin	White-beaked dolphin	Patterned dolphin sp.	Dolphin species
Total	**2**	**3**	**2**	**7**

179. The total number of dolphin species recorded during the aerial surveys from September 2015 to August 2017 for NV West and 4km buffer was 14 dolphins, of which 4 were identified as white-beaked dolphins (Table 12.15).

Table 12.15 Dolphin species recorded during aerial surveys of NV West undertaken between September 2015 and February 2017 for the OWF area and 4km buffer

Date	White-beaked dolphin	Dolphin species
September 2015	0	11
October 2015	0	0
November 2015	0	0
December 2015	0	0
January 2016	0	0
February 2016	0	0
March 2016	0	1
April 2016	0	0
May 2016	0	0
June 2016	0	0
July 2016	0	0
August 2016	0	0
September 2016	0	0
October 2016	0	0
November 2016	0	0
December 2016	0	0
January 2017	0	1
February 2017	0	0
March 2017	0	0
April 2017	0	0
May 2017	0	0
June 2017	4	1
July 2017	0	0
August 2017	0	0
Total	**4**	**14**

180. It was not possible to estimate abundance or density estimates based on the very low sightings of dolphin species during the Norfolk Vanguard aerial surveys.

181. Taking into account the very low numbers and no or infrequent sightings during the site specific surveys, the East Anglia Zone surveys along with the SCANS-II and SCANS-III surveys, white-beaked dolphin, bottlenose dolphin and common dolphin have not been assessed further or included in the impact assessment as there is a very low risk of having a significant, if any, impact on these species.

182. The cetacean species included in the assessment has been agreed with the marine mammal ETG (Table 12.4).

12.6.1.3 Minke whale

12.6.1.3.1 Distribution

183. Minke whales are widely distributed along the Atlantic seaboard of Britain and Ireland and throughout the North Sea. The JNCC Cetacean Atlas (Reid *et al.,* 2003), indicates that minke whale occur regularly in the North Sea to the north of Humberside, but are comparatively scarce in the southern North Sea. Animals are present throughout the year, but most sightings are between May and September (Reid *et al.,* 2003). DECC (2016) support this, stating that sightings rarely extend past Dogger Bank, but that occasional sightings of minke whale are made as far south as Flamborough Head and the north Humberside coastlines between July and October (DECC, 2016).

184. Higher densities of minke whale have been recorded along the margins of Dogger Bank and adjacent areas in spring and summer (de Boer, 2010; Gilles *et al*., 2012; Hammond *et al*., 2013). Few sightings of minke whale have been made further south of these areas and it is thought that they probably enter the North Sea from the north (DECC, 2016). Minke whales appear to move into the North Sea at the beginning of May and are present throughout the summer until October (Northridge *et al*., 1995).

185. As outlined in section 12.6.1, during the Rosyth to Zeebrugge ferry trips in 2017 and 2016 the cetacean species recorded included minke whale in May 2017. On the Felixstowe to Vlaardingen ferry route across the southern North Sea, one minke whale was recorded in May 2016 and on the Hull to Zeebrugge ferry route an unidentified whale was recorded in July 2017 (MARINElife, 2017). It should be noted, that these sightings could have been made be at any point between the two port locations.

12.6.1.3.2 Abundance and density estimates

Celtic and Greater North Seas MU

186. Genetic evidence suggests that the minke whales of the North Atlantic are likely to be a single genetic population (Anderwald *et al*., 2012). Therefore, IAMMWG (2015) considers a single MU is appropriate for minke whales in European waters.

187. The abundance of minke whales in the Celtic and Greater North Seas (CGNS) MU is 23,528 animals (CV = 0.27; 95% CI = 13,989-39,572; IAMMWG, 2015). The estimate was derived from SCANS-II (Hammond *et al*., 2013) and CODA (Macleod *et al*., 2009)

and is likely to be underestimated. The IAMMWG (2015) note the abundance of minke whales is highly seasonal, with abundance peaking during migration south into waters around the UK for summer.

SCANS data

188. SCANS-I in July 1994 estimated 8,445 minke whale (95% CI = 5,000-13,500) (Hammond *et al.,* 2002). The SCANS-II survey gave an overall estimate of 18,958 minke whale (CV = 0.347); with 10,786 minke whale (CV = 0.29) for the North Sea area; and 13,734 minke whale (CV = 0.41; 95%CI = 9,800 – 36,700) within an area comparable to the 1994 survey (Hammond *et al.,* 2013). Although these estimates were not significantly different, there were noticeable changes in distribution between the two surveys (analogous to those observed in harbour porpoise) which again is most likely to be linked to changes in prey availability.

189. SCANS-II estimated the average minke whale density across survey block B to be 0.01 individuals per km^2 and the estimated abundance was 1,199 individuals (CV = 0.98; Hammond *et al*., 2013). The high CV value indicates there is a large amount of uncertainty around this estimate, this is a function of the very low sightings rates; only two groups were sighted in block B. Hammond *et al.* (2013) confirms that these two sightings were in the vicinity of the Channel Islands, and not in close proximity to the Norfolk Vanguard offshore project area.

190. For the entire SCANS-III survey area (not the same area as SCANS-II), minke whale in the summer of 2016 was estimated to be 14,759 with an overall estimated density of $0.0008/km^2$ (CV = 0.327; 95% CI = 7,908-27,544; Hammond *et al*., 2017).

191. NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O. Minke whale were not recorded in survey block L during SCANS-III survey. The estimated abundance in SCANS-III survey block O was 603 minke whale (CV=0.62; 95% CI = 109-1,670), with an estimated density of 0.010 minke whale per km^2 (CV=0.62; Hammond *et al*., 2017). However, it should be noted that the minke whale sightings in SCANS-III survey block O were to the north of the Norfolk Vanguard offshore project area.

East Anglia Zone surveys

192. Aerial surveys undertaken for the former East Anglia Zone did not record any minke whale (EAOW, 2012a). In addition, no minke whale, or large cetaceans (which had the potential to be minke whale) were recorded in the East Anglia THREE site plus buffer during the 24 months of aerial surveys (EATL, 2015). No minke whale were observed within the 24 months of aerial surveys or the 12 months of boat-based surveys for East Anglia ONE (EAOW, 2012b).

Norfolk Vanguard site specific surveys

193. No minke whale or potential minke whale sightings were made in the aerial surveys for either NV East or NV West.

194. As a result of the lack of sightings during the site specific surveys, East Anglia Zone surveys and the lack of sightings in this area of the North Sea during the SCANS-II and SCANS-III surveys, minke whale have not been assessed further or included in the impact assessment as there is a very low risk of having a significant, if any, impact on this species.

195. The cetacean species included in the assessment has been agreed with the marine mammal ETG (Table 12.4).

12.6.1.4 Designated sites and conservation importance of cetaceans

196. As discussed in section 12.2.1, all cetaceans in UK waters are classed as European Protected Species (EPS) under Annex IV of the Habitats Directive (EU Directive 92/43/EEC) and therefore internationally important. Bottlenose dolphin and harbour porpoise are listed under Annex II of the Habitats Directive and are afforded protection through the designation of Natura 2000 sites.

197. Bottlenose dolphin has not been identified during Norfolk Vanguard aerial surveys and no bottlenose dolphin were positively sighted during the aerial surveys of the adjacent East Anglia THREE site (EATL, 2015). During SCANS-III surveys in summer 2016, no bottlenose dolphin were recorded in or around the area of Norfolk Vanguard (Hammond *et al*., 2017). During the SCANS-II surveys, only two bottlenose dolphin groups were sighted within the survey block which encompasses the East Anglia Zone; resulting in an estimated density of 0.0032 (CV = 0.74) individuals per km2 (Hammond *et al*., 2013). There are currently seven Management Units (MU) for bottlenose dolphin in UK waters; Norfolk Vanguard is located in the Greater North Sea (GNS) MU, which has an estimated population size of zero (IAMMWG, 2015). Taking into account the very low occurrence of sightings in and around the Norfolk Vanguard offshore project area and the assessment of the GNS MU population size by the IAMMWG, this species was screened out from further assessment in the EIA and for the HRA (Royal HaskoningDHV, 2017a, b, c). The species included in the EIA and assessments for the HRA have been agreed with the marine mammal ETG (Table 12.4).

198. For harbour porpoise, connectivity was considered potentially possible between Norfolk Vanguard and any Natura 2000 site within the North Sea Management Unit (MU) (IAMMWG, 2015). The extent of the North Sea MU has been agreed during consultation with the marine mammals ETG (February 2017), as the most

appropriate population which any harbour porpoise occurring within Norfolk Vanguard may be part of.

199. The HRA screening considered any Natura 2000 site within the harbour porpoise North Sea MU, where the species is considered as a grade A, B or C feature. Grade D indicates a non-significant population (JNCC, 2017c). All Natura 2000 sites outwith the harbour porpoise North Sea MU area were screened out from further consideration.

200. The approach to HRA screening primarily focused on the potential for connectivity between individual marine mammals from designated populations and the proposed Norfolk Vanguard project (i.e. demonstration of a clear source-pathway-receptor relationship). This was based on the distance of Norfolk Vanguard from the designated site, the range of each effect and the potential for animals from a site to be within range of an effect.

201. Designated sites were screened on the basis of the following:

- The distance between the potential impact range of the proposed project and any sites with a marine mammal interest feature which are within the range for which there could be an interaction e.g. the pathway is not too long for significant noise propagation.
- The distance between the proposed project and resources on which the interest feature depends (i.e. an indirect effect acting though prey or access to habitat) and which is within the range for which there could be an interaction i.e. the pathway is not too long.
- The likelihood that a foraging area or a migratory route occurs within the zone of interaction of the proposed project (applies to mobile interest features when outside the SAC).

202. In total 41 sites were initially considered in the screening process for harbour porpoise and these sites were assessed for any potential effects from indirect impacts through effects on prey species; underwater noise; and vessel interactions. Based on the approach outlined above, 40 of these sites were screened out from further consideration in the assessments for the HRA, and the Southern North Sea cSAC for harbour porpoise was screened in to be assessed further in the HRA (see HRA Screening, Appendix 5.1 of the Report to inform the HRA (document reference 5.3); Royal HaskoningDHV, 2017c).

Southern North Sea candidate Special Area of Conservation

203. The Southern North Sea (SNS) cSAC has been recognised as an area with persistent high densities of harbour porpoise (JNCC, 2017b). The cSAC has a surface area of 36,951km^2 and covers both winter and summer habitats of importance to harbour

porpoise, with approximately 66% of the candidate site being important in the summer and the remaining 33% of the site being important in the winter period (Figure 12.1; JNCC, 2017b).

204. Both NV East and NV West lie wholly within the SNS cSAC. NV East is located wholly within the summer area. The majority of NV West is located within the summer area, with a small segment of the southern edge of the site being located within the winter area (Figure 12.1).

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

206. However, it was agreed with the marine mammal ETG at the EPP meeting on 15th February 2017 that the estimate that the SNS cSAC could support 17.5% of the UK North Sea reference population could be considered in the EIA and in the assessments for the HRA alongside the North Sea MU reference population and the SNS cSAC winter and summer areas. Therefore, for information purposes, Appendix 12.4 presents an assessment on the estimated number of harbour porpoise that the SNS cSAC site could support of 29,384 harbour porpoise. This estimate is based on the UK North Sea MU area (322,897km^2), the overall harbour porpoise density estimate of 0.52/km^2 (CV = 0.18) for the North Sea MU area from the SCANS-III survey (Hammond *et al*., 2017) and the estimated UK North Sea MU population of 167,906 harbour porpoise, with 17.5% of the population within the UK part of the North Sea MU of approximately 29,384 harbour porpoise.

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

208. The draft Conservation Objectives for the site are (JNCC and NE, 2016):

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 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.

209. These draft Conservation Objectives "are based on considerations of the ecological requirements of the species within the site, yet their interpretation is contextualised in their contribution to maintaining FCS at a wider scale. With regard the SNS site, harbour porpoise need to be maintained rather than restored" (JNCC and NE, 2016).

210. The SNCBs current advice (Natural England, June 2017) on the assessment of impacts on the SNS harbour porpoise cSAC is that:

- A distance of 26km from an individual percussive piling location should be used to assess the area of SNS cSAC habitat which harbour porpoise may be disturbed from during piling operations (noting previous references made during industry workshops to the potential for a reduction in this measure, where project specifics allow).
- Displacement of harbour porpoise should not exceed 20% of the seasonal component of the SNS cSAC at any one time and or on average exceed 10% of the seasonal component of the SNS cSAC over the duration of that season.
- The effect of the project should be considered in the context of the seasonal components of the SNS cSAC, rather than the SNS cSAC as a whole.
- A buffer of 10km around seismic operations and 26km around UXO detonations should be used to assess the area of cSAC habitat from which harbour porpoise may be disturbed.

211. The SNCBs also advise (Natural England, June 2017) the planned approach to in-combination assessment for Norfolk Vanguard to consider the following:

- Inclusion of seismic surveys within 10km of the SNS cSAC;
- Inclusion of projects undertaking percussive piling within 26km from the SNS cSAC boundary (or relevant seasonal component); and
- Inclusion of UXO detonation within 26km of the SNS cSAC.

212. This latest SNCB advice has been used in the assessments for the EIA and is incorporated in the assessments for the HRA. Guidance on managing noise disturbance within the SNS cSAC is currently under review and subject to change.

12.6.2 Pinnipeds

213. Two seal species live and breed in UK waters: grey seal and harbour (or common) seal (SCOS, 2017). Both species are considered in the EIA and have been considered in the assessments for the HRA.

214. Other seal species that occasionally occur in UK coastal waters, include ringed seals (*Phoca hispida*), harp seals (*Phoca groenlandica*), bearded seals (*Erignathus barbatus*) and hooded seals (*Cystophora crystata*), all of which are Arctic species and are only rarely encountered in UK water (SCOS, 2017).

215. The seal species included in the assessment has been agreed with the marine mammal ETG (Table 12.4).

12.6.2.1 Grey seal

12.6.2.1.1 Distribution

216. Grey seals only occur in the North Atlantic, Barents and Baltic Sea with their main concentrations on the east coast of Canada and United States of America and in north-west Europe (SCOS, 2017).

217. Approximately 38% of the worlds grey seals breed in the UK and 88% of these breed at colonies in Scotland with the main concentrations in the Outer Hebrides and in Orkney. There are also breeding colonies in Shetland, on the north and east coasts of mainland Britain and in south-west England and Wales (SCOS, 2017).

218. SMRU, in collaboration with others, deployed 269 telemetry tags on grey seals around the UK between 1988 and 2010 (Russell and McConnell, 2014). The telemetry data for grey seal adults (Plate 12.6.a) and pups (Plate 12.6.b) indicate that very few tagged greys seals have been recorded in and around the Norfolk Vanguard offshore project area (OWF sites and offshore cable corridor), with the tracks of only one grey seal pup tagged at the Isle of May in 2002 and one adult grey seal in the vicinity of the Norfolk Vanguard offshore project area (Plate 12.6; Russell and McConnell, 2014).

219. Tags deployed on grey seals at Donna Nook and Blakeney Point in May 2015, indicated that they used multiple haul-out sites; with one grey seal hauling out in the Netherlands and one in Northern France (Russel, 2016). Plate 12.7 shows the tagged seal movements along the east coast of England and indicates that grey seal travel

between haul-out sites along the east coast of England, as well as to the north of France and up to the Firth of Forth and across Fladden Ground and Dogger Bank (Russell, 2016). Russell *et al*. (2013) found that between 21% and 58% of female grey seals used different regions for breeding and foraging.

220. For the East Anglia THREE EIA (EATL, 2015), East Anglia THREE Ltd (EATL) commissioned SMRU Marine Ltd to investigate the connectivity between tagged grey seal and the East Anglia THREE site plus a 20km buffer area (Appendix 12.3 of the East Anglia THREE ES; EATL, 2015[3]). The study was based on the SMRU database of telemetry data of tagged grey seal pups and adults from important breeding locations in UK, including the Farne Islands, Donna Nook, Abertay Sands and the Isle of May from 1988 to 2008. The study indicated that none of the 92 tagged grey seals aged one year or over entered the East Anglia THREE site plus a 20km buffer area or surrounding area. However, the tracks did indicate the movement of grey seals between MUs on the east coast of England and Scotland.

221. The north Dutch coastline is an important foraging zone and migration route for grey seal (Brasseur *et al*., 2010). A study on the grey seal development in the Dutch part of the Wadden Sea shows that the growth of the breeding population is fuelled by the annual immigration of grey seals from the UK (Brasseur *et al*. 2014).

222. For the East Anglia THREE ES (EATL, 2015), EATL also commissioned IMARES to explore connectivity between tagged grey seal at haul out sites at Dutch colonies and the East Anglia THREE site plus a 20km buffer area (Appendix 12.4 of the East Anglia THREE ES; EATL, 2015[4]). From the Dutch telemetry studies, a total of 77 grey seal were tagged at haul out sites in the Netherlands between 2005 and 2013. Of these seals, six were found to travel within 20km of the East Anglia THREE site. Of these six seals, three entered the offshore cable corridor and two were within the East Anglia THREE site. Although, it is likely all grey seals from Dutch sites spent less than 2% of their 'time-at-sea' within the East Anglia THREE site. However, the study did indicate the movement of grey seal between the UK and Dutch sites.

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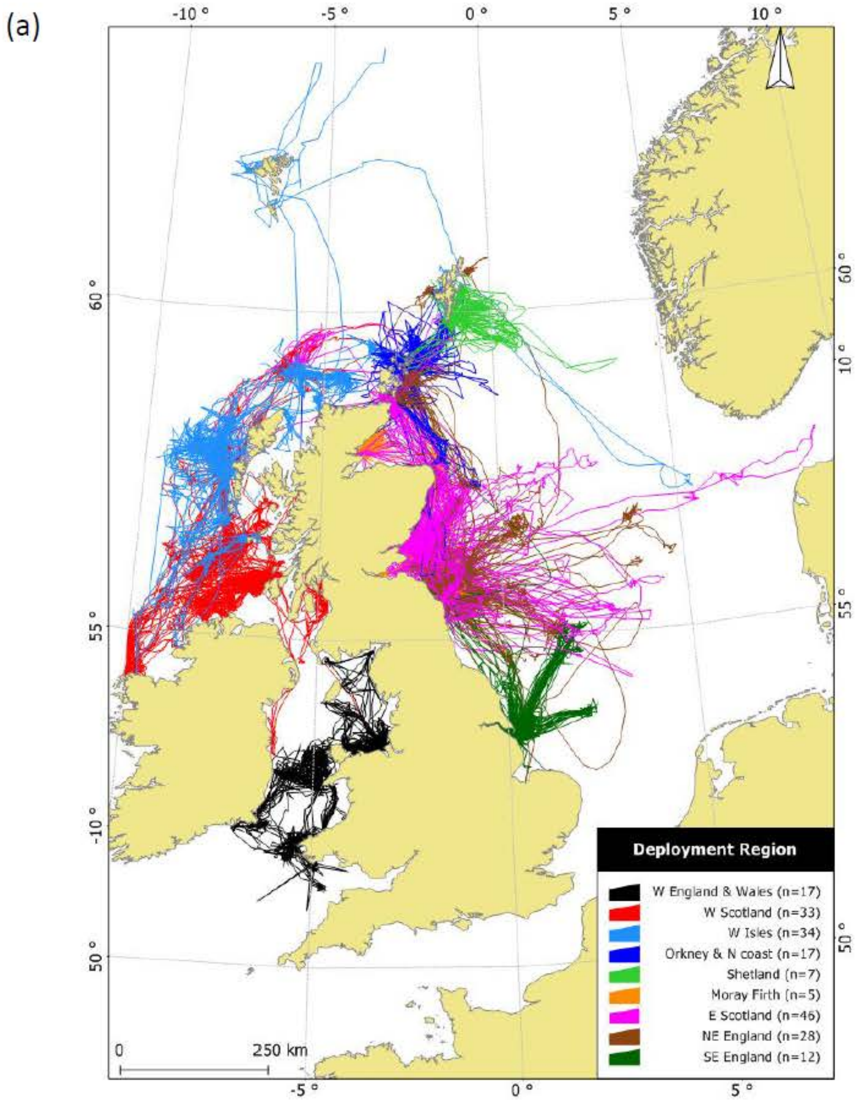
[3] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000296-6.3.12%20(3)%20Volume%203%20Chapter%2012%20Marine%20Mammal%20Ecology%20Appendix%2012.3.pdf

[4] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000297-6.3.12%20(4)%20Volume%203%20Chapter%2012%20Marine%20Mammal%20Ecology%20Appendix%2012.4.pdf

223. There is a considerable amount of movement of grey seals that occurs (as observed from telemetry data) among the different areas and regional subunits of the North Sea and no evidence to suggest that grey seals on the North Sea coasts of Denmark, Germany, the Netherlands or France are independent from those in the UK (SCOS, 2017).

224. Spatial distributions indicate that grey seals have homogeneous usage near-shore, that they typically range widely and frequently travel over 100km between haul-out sites, and that they tend to spend approximately 15% of their time far-offshore, e.g. more than 50km from the coast (Russell and McConnell, 2014; SCOS, 2017).

225. Marine Scotland commissioned SMRU to produce maps of grey seal distribution in UK waters (Russell *et al*., 2017). These maps were produced by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites. The resulting maps show estimates of mean seal usage (seals per 5 km x 5 km grid cell) within UK waters. The maps indicate that grey seal usage is relatively low in and around the Norfolk Vanguard offshore project area and higher along the coast (Figure 12.2; Russell *et al*., 2017).



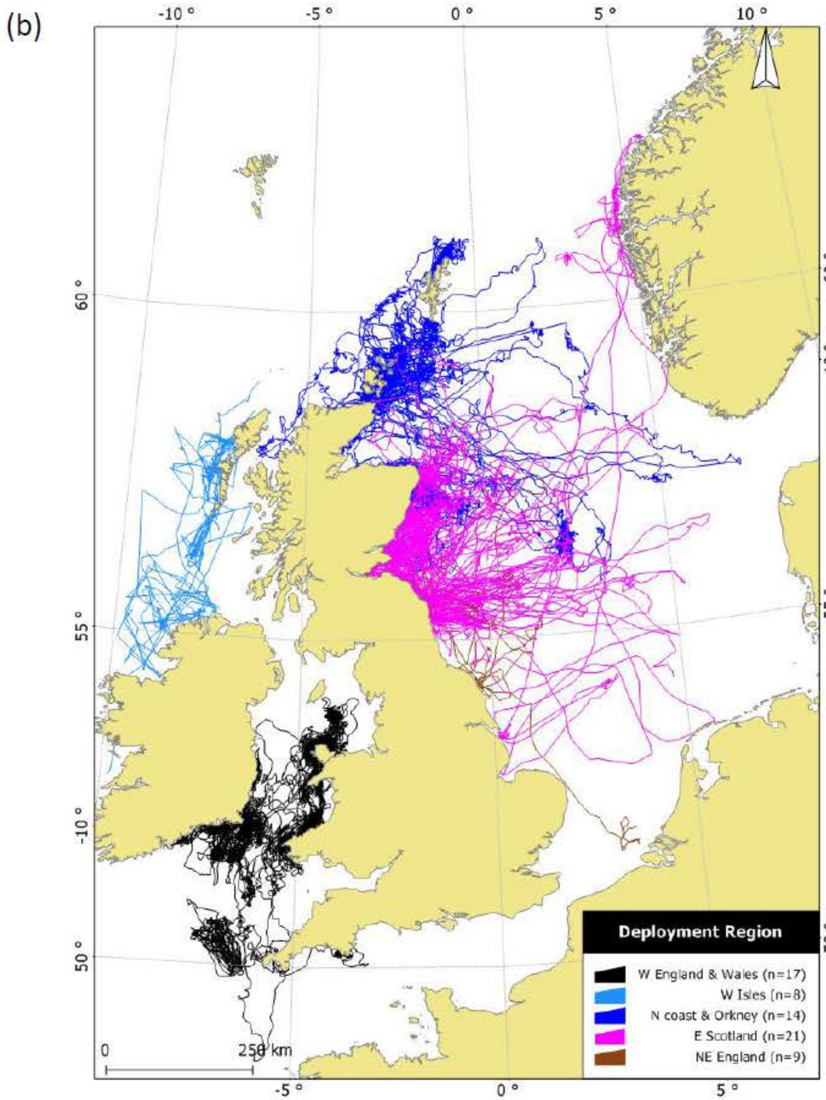


Plate 12.6 Telemetry tracks by deployment region for grey seals aged (a) one year or over and (b) pups (Source: Russell and McConnell, 2014)

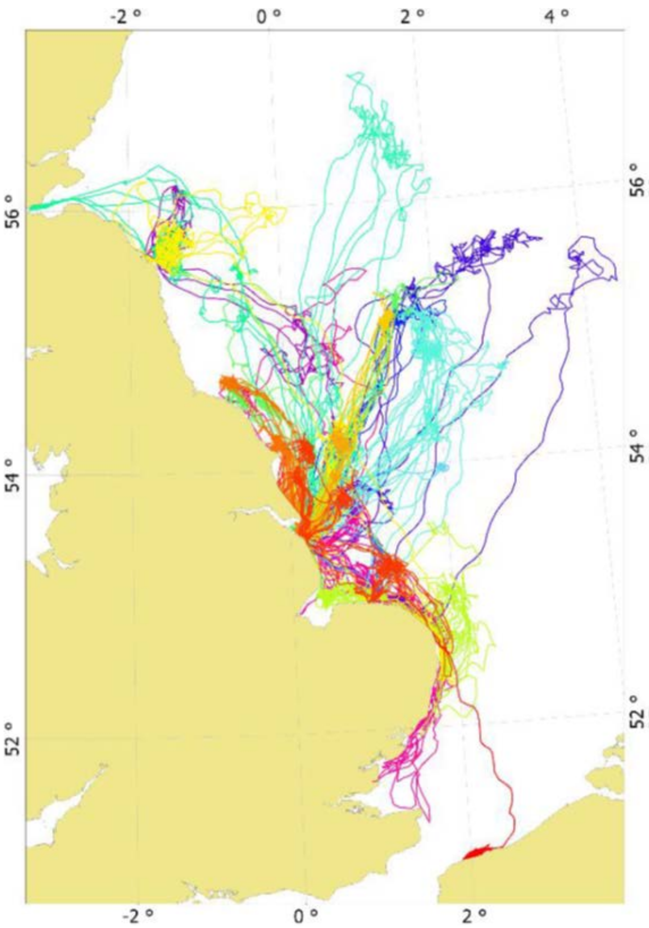


Plate 12.7 Tagged grey seal movements along the East coast of England (Source: Russell, 2016)

12.6.2.1.2 Haul-out sites

226. Compared with other times of the year, grey seals in the UK spend longer hauled out during their annual moult (between December and April) and during their breeding season (SCOS, 2017).

227. In eastern England, pupping occurs mainly between early November and mid-December (SCOS, 2017). Pups are typically weaned 17 to 23 days after birth, when they moult their white natal coat, and then remain on the breeding colony for up to two or three weeks before going to sea. Mating occurs at the end of lactation and then adult females depart to sea and provide no further parental care (SCOS, 2017).

228. In the UK, grey seals typically breed on remote uninhabited islands or coasts and in small numbers in sea caves, where they can avoid busy beaches and storm surges, although they are also known to breed on some exposed beaches. For example, at Donna Nook in Lincolnshire, grey seals have become habituated to human disturbance and over 70,000 people visit this colony during the breeding season with no apparent impact on the breeding seals (SCOS, 2016).

229. NV West is located approximately 47km offshore (at the closest point). Principal grey seal haul-out sites at Scroby Sands are approximately 47km from the site, the distance to Blakeney Point National Nature Reserve (NNR) is approximately 88km, the distance to The Wash is approximately 79km and Donna Nook is located approximately 149km from the Norfolk Vanguard OWF sites (Figure 12.4).

230. Historically, Donna Nook has been the most important breeding site for grey seals on the east coast of England, however, there has been a considerable increase in the number of pups born at Blakeney Point, with this site now the biggest grey seal breeding colony in England, overtaking Donna Nook (SCOS, 2016).

231. The main breeding and haul-out sites for grey seal on the east coast of England are located at Blakeney Point (within the Wash and North Norfolk Coast SAC which is designated for harbour seal), at Horsey (located in the Winterton-Horsey Dunes SAC, although grey seal are not currently listed as a qualifying feature) and at Donna Nook in the Humber Estuary SAC (Figure 12.4).

232. While grey seal are not currently a qualifying feature at the North Norfolk SAC (which includes Blakeney Point) or Winterton-Horsey Dunes SAC, it is recognised that these sites are important for the population, as breeding, moulting and haul-out sites. Therefore, consideration will be given to grey seal as part of the North Norfolk SAC and Winterton-Horsey Dunes SAC in the assessments for the HRA, to determine if there is the potential for any disturbance to grey seals hauled out at these sites.

233. At Horsey on the Norfolk coastline from Winterton to Waxham, grey seal use the haul-out sites for breeding and moulting. Counts undertaken by the Friends of Horsey Seals wardens in the 2016-17 breeding season indicated that the overall numbers of births increased from 1,236 in 2015-2016 to 1,487. The first births were recorded in early November and birth rate peaked on the 2nd December 2016 (Rothney, 2017). Counts undertaken in the 2017-18 breeding season indicated that the total pups born this season were 1,825 (Friends of Horsey, 2018). Counts in 2015-16, during a 15 week period from 15th October 2015 to 21st January 2016, indicated that the number of adult grey seals recorded varied with the stage in the breeding cycle. The recent counts indicate that the breeding colony of grey seals at Horsey-Winterton is continuing to increase in numbers and expand its distribution (Rothney, 2016).

234. The landfall for the Norfolk Vanguard offshore export cables will be at Happisburgh South, approximately 11km from the Horsey seal haul-out sites to the south and 43km from the Blakeney Point haul-out site to the north (Figure 12.4).

12.6.2.1.3 Diet and foraging

235. Grey seals are generalist feeders, foraging mainly on the sea bed at depths of up to 100m although they are probably capable of feeding at all the depths found across the UK continental shelf (SCOS, 2017).

236. In the North Sea, principal prey items are sandeel, whitefish (such as cod, haddock, whiting and ling *Molva molva*) and flatfish (plaice *Pleuronectes platessa*, sole, flounder, dab *Limanda limanda*) (Hammond and Grellier, 2006). Amongst these, sandeels are typically the predominant prey species. Diet varies seasonally and from region to region (SCOS, 2016).

237. Food requirements depend on the size of the seal and fat content (oiliness) of the prey, but an average consumption estimate of an adult is 4 to 7 kg per seal per day depending on the prey species (SCOS, 2017).

238. Grey seals typically forage in the open sea and return regularly to haul out on land where they rest, moult and breed. They may range widely to forage and frequently travel. Foraging trips can last anywhere between one and 30 days (SCOS, 2017).

239. Tracking of individual seals has shown that most foraging probably occurs within 100km of a haul-out site, with ranges of approximately 145km (Thompson *et al*., 1996), although they can feed up to several hundred kilometres offshore, with ranges of 1,088 to 6,400km recorded (Dietz *et al*., 2003). Individual grey seals based at a specific haul-out site often make repeated trips to the same region offshore, but will occasionally move to a new haul-out site and begin foraging in a new region (SCOS, 2017). Movements have been recorded between haul-out sites on the east coast of England and the Outer Hebrides (SCOS, 2017). Studies of regular foraging and dispersal between winter breeding sites, and summer foraging and haul out sites indicates ranges of 1,000km (e.g. McConnell *et al*., 1992).

240. Telemetry studies of grey seal in the UK have identified a highly heterogeneous spatial distribution with a small number of offshore 'hot spots' continually utilised (Matthiopolous *et al.,* 2004; Russell *et al*., 2017).

241. Data analyses of tagged seals indicate that foraging distribution is related to their breeding distribution (Russell and McConnell, 2014). Female grey seal do not forage while suckling their pups. Therefore, the movement of female grey seals differs between the foraging and breeding seasons. Russell *et al*. (2013) found that between 21 and 58% of females used different regions for foraging and breeding.

242. The resulting tracks from the tags also show grey seals range far from land and pups may have more long ranging movements than adults (Plate 12.6; Russell and McConnell, 2014).

12.6.2.1.4 Abundance and density estimates

243. Grey seal population trends are assessed from the counts of pups born during the autumn breeding season, when females congregate on land to give birth (SCOS, 2017). The pup production estimates are converted to estimates of total population size (1+ aged population) using a mathematical model and projected forward (SCOS, 2017).

244. The most recent surveys of the principal grey seal breeding sites Scotland, Wales, Northern Ireland and south-west England, resulted in an estimate of 60,500 pups (95% CI = 53,900-66,900; SCOS, 2017). When the pup production estimates are converted to estimates of total population size, there was an estimated 141,000 grey seals in 2016 (approximate 95% CI = 117,500-168,500; SCOS, 2017).

245. The estimated adult UK grey seal population size in regularly monitored colonies in 2016 was 128,200 (95% CI = 106,200-154,400), an increase of approximately 1% on the 2015 estimate (SCOS, 2017).

246. In the southern North Sea, the rates of increase in pup production from 2010 to 2014 (by an average 22% p.a.) suggests that there must be some immigration from colonies further north (SCOS, 2016).

247. The most recent counts of grey seal in the August surveys 2008-2016, estimated that the total count of grey seals in the UK was 40,662 (SCOS, 2017).

Management units

248. The most recent August counts (2016) of grey seal at haul-out sites in the south-east England MU provides an estimated abundance of 6,085 grey seal (SCOS, 2017). This includes 3,964 grey seals at Donna Nook, 431 grey seals at The Wash, 355 grey seals at Blakeney Point, 642 grey seals at Scroby Sands and 481 grey seals along the Essex and Kent coast (SCOS, 2017).

249. For the north-east MU there is an estimated 6,948 grey seal, based on the most recent counts in 2016 (SCOS, 2017). This includes 6,767 grey seals in Northumberland and 22 at The Tees (SCOS, 2017).

250. It should be noted, that, grey seal summer counts are known to be more variable than harbour seal summer counts. Therefore, SCOS (2017) suggests that caution is advised when interpreting these numbers.

251. As outlined in section 12.6.2.1.1, the north Dutch coastline is an important foraging zone and migration route for grey seal. The coordinated aerial, boat and land surveys of the Dutch, German and Danish Wadden Sea grey seal areas including Helgoland (Germany) are aimed at estimating changes in numbers of grey seal in the Wadden Sea area. Annual surveys are conducted in the Wadden Sea, during the moult and breeding season by the Trilateral Seal Expert Group (TSEG). The most recent TSEG counts for adult grey seals were conducted by aerial surveys during the moulting period in the spring of 2017. Studies show that in moult period the animals present are not necessarily animals breeding in the Wadden Sea and considerable exchange occurs with the much larger UK population (Brasseur *et al*., 2015). In total, the number of grey seal recorded in 2017 increased by 10% compared to 2016, to 5,445 in the Wadden Sea area (TSEG, 2016a, 2017a).

Seal density maps

252. The latest seal at sea maps (Russell *et al*., 2017), were produced by SMRU by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites. The resulting maps show estimates of mean seal usage (seals per 5km x 5km grid cell; Figure 12.2).

253. Table 12.16 shows the grey seal density estimates for Norfolk Vanguard which have been calculated from the 5km x 5km cells (Russell *et al*., 2017) based on the area of overlap with the Norfolk Vanguard offshore project area (Figure 12.2).

Table 12.16 Grey seal density estimates (based on Russell *et al*., 2017)

Density Estimate	Individuals per km^2				
	Offshore Cable Corridor	NV West	NV East	NV OWF sites	NV Offshore Project Area
Lower at-sea	0.00002	0.0004	0.00005	0.0002	0.0002
Mean at-sea	0.08	0.002	0.00009	0.001	0.02
Upper at-sea	0.16	0.004	0.0001	0.002	0.05

254. Within the offshore wind farm sites (592km^2) the upper at-sea density of grey seal is estimated to be 0.002/km^2. Within the offshore cable corridor area (237km^2) the upper at-sea density of grey seal is estimated to be 0.16/km^2.

East Anglia Zone surveys

255. Aerial surveys conducted for the East Anglia Zone (Zonal Environmental Appraisal Report) from November 2009 to April 2011, did not record any observations of seals (EAOW, 2012c).

256. During aerial surveys at the East Anglia ONE site (EAOW, 2012b) no observations of grey seal were made. Grey seals were also not recorded during boat based surveys

at the East Anglia ONE site, suggesting that there is low usage of the East Anglia ONE site (EAOW, 2012b).

257. Aerial surveys conducted for East Anglia THREE commenced in September 2011 and were completed in August 2013. The survey area consisted of the East Anglia THREE site and 4km buffer around it. During East Anglia THREE surveys only two seals were recorded, observations of seals were not classified to a particular species (EATL, 2015). The results of the East Anglia THREE aerial surveys support the tagging data and suggest that there is low usage of the former East Anglia Zone.

Norfolk Vanguard site specific surveys

258. The total number of seal species recorded during the aerial surveys for NV East, including the EA4 surveys, from March 2012 to April 2016 (32 months) for NV East and 4km buffer was five seals, these were not identified to species (Table 12.17).

Table 12.17 Seals recorded during aerial surveys of NV East, including EA4 surveys, undertaken between March 2012 and April 2016 for the OWF area and 4km buffer

Date	Seal species
March 2012	0
April 2012	0
May 2012	0
June 2012	0
July 2012	2
August 2012	0
September 2012	0
October 2012	0
November 2012	1
December 2012	0
January 2013	0
February 2013	0
March 2013	1
April 2013	0
May 2013	0
June 2013	0
July 2013	0
August 2013	0
September 2013	0
October 2013	0
November 2013	0
December 2013	0
January 2014	0
February 2014	0
September 2015	0
October 2015	0
November 2015	0
December 2015	1
January 2016	0
February 2016	0
March 2016	0
April 2016	0

Date	Seal species
Total	**5**

259. The total number of seal species recorded during the aerial surveys for NV West from September 2015 to February 2017 for NV West and 4km buffer was four seals, two of which were identified as grey seal (Table 12.18).

Table 12.18 Seals recorded during aerial surveys of NV West undertaken between September 2015 and February 2017 for the OWF area and 4km buffer

Date	Seal species
September 2015	0
October 2015	0
November 2015	0
December 2015	0
January 2016	0
February 2016	0
March 2016	0
April 2016	0
May 2016	1
June 2016	0
July 2016	0
August 2016	0
September 2016	0
October 2016	0
November 2016	0
December 2016	0
January 2017	1 (grey seal)
February 2017	1
March 2017	0
April 2017	0
May 2017	0
June 2017	1 (grey seal)
July 2017	0
August 2017	0
Total	**4**

260. As the sightings data was too low within the Norfolk Vanguard OWF sites to determine a robust site specific density estimate for grey seal, the SMRU seals at-sea density data (Table 12.16; Russell *et al*., 2017) has been used in the assessment, as agreed with the marine mammal ETG (meeting 15th February 2017; Table 12.4).

12.6.2.1.5 Reference population for assessment

261. In accordance with the approach agreed with the marine mammals ETG (Table 12.4), the reference population extent for grey seal incorporates the south-east England, north-east England and east coast of Scotland MUs (IAMMWG, 2013; SCOS, 2017) and the Waddenzee region (TSEG, 2017a).

262. The telemetry studies outlined in sections 12.6.2.1.1 and 12.6.2.1.3 (Plate 12.6 and Plate 12.7justify the inclusion of UK south-east England MU, north east England MU, east coast of Scotland MU and the Waddenzee region in the reference population for this assessment.

263. It is acknowledged that the UK grey seal counts are based on surveys conducted in August and the Waddenzee region is based on counts in winter / spring (and is not a population estimate). As outlined in section 12.6.2.1.4, when the pup production estimates from autumn counts are converted to estimates of total population size, there was an estimated 141,000 grey seals in 2016 (approximate 95% CI = 117,500-168,500; SCOS, 2017). The most recent counts of grey seal in the August surveys 2008-2016, estimated that the total count of grey seals in the UK was 40,662 (SCOS, 2017). Therefore, using the August grey seal counts for the reference population is a precautionary approach and is likely to be an underestimate of the number of grey seals in the UK MUs.

264. The reference population is therefore based on the most recent counts for the:

- South-east England MU = 6,085 grey seal (SCOS, 2017);
- North-east England MU = 6,948 grey seal (SCOS, 2017);
- East Coast Scotland MU = 3,812 grey seal (SCOS 2017); and
- The Waddenzee region = 5,445 grey seal (TSEG, 2017a).

265. The total reference population for the assessment is therefore 22,290 grey seal. In addition, the assessment of the potential impacts will also be assessed on the south-east England MU of 6,085 grey seal.

12.6.2.2 Harbour seal

12.6.2.2.1 Distribution

266. Harbour seals have a circumpolar distribution in the Northern Hemisphere and are divided into five sub-species. The population in European waters represents one subspecies *Phoca vitulina vitulina* (SCOS, 2017).

267. On the east coast of Britain harbour seal distribution is generally restricted, with concentrations in the major estuaries of the Thames, The Wash and the Moray Firth (SCOS, 2017).

268. SMRU, in collaboration with others, has deployed around 344 telemetry tags on harbour seals around the UK between 2001 and 2012 (Russell and McConnell, 2014). The tracks indicate that very few tagged harbour seals have been recorded in the immediate vicinity of NV East and NV West, with tracks moving along the coast

between The Wash and the Thames estuaries (Plate 12.8). This is reflected in the harbour seal density estimates for the Norfolk Vanguard OWF sites compared to the offshore cable corridor (Table 12.19), although harbour seal numbers in both Norfolk Vanguard OWF sites and the offshore cable corridor are very low. Most tracks of seals tagged in The Wash appear to move directly out to sea or to the north of The Wash (Plate 12.8).

269. Spatial distributions indicate harbour seals persist in discrete regional populations, display heterogeneous usage and generally stay within 50km of the coast (Russell and McConnell, 2014).

270. For the East Anglia THREE EIA (EATL, 2015), EATL commissioned SMRU Marine Ltd to investigate the connectivity between tagged harbour seal and the East Anglia THREE site plus a 20km buffer area (Appendix 12.3 of the East Anglia THREE ES; EATL, 2015). The study was based on the SMRU database of telemetry data of harbour seal juveniles and adults from tagging locations including the Wash and the Thames Estuary from 2003 to 2012, including data from the Zoological Society of London seal tagging study. The study indicated that none of the 43 tagged harbour seals aged one or above entered the East Anglia THREE site plus a 20km buffer area or surrounding area. The study indicated that movements of harbour seal were mostly restricted to the south-east MU.

271. For the East Anglia THREE ES (EATL, 2015), EATL also commissioned IMARES to explore connectivity between tagged harbour seal at haul out sites at Dutch colonies and the East Anglia THREE site plus a 20km buffer area (Appendix 12.4 of the East Anglia THREE ES; EATL, 2015). From the Dutch telemetry studies, a total of 273 harbour seal were tagged at sites in the Netherlands between 1997 and 2013. Of these seals, 10 were found to travel within 20km of the EA3 site. Of these 10 seals, six entered the offshore cable corridor and two were within the East Anglia THREE site. Although, it is likely all but one harbour seal spent less than 2% of their 'time-at-sea' within the area, with an exception being a harbour seal tagged in 2007 which spent at least 2% and up to 17% of its 'time-at-sea' within the offshore cable corridor. The Dutch tagging data illustrate the long ranging movements of harbour seal and levels of connectivity between Dutch haul out sites and those on the east coast of England.

272. The SMRU maps of harbour seal distribution in UK waters (Russell *et al.*, 2017), based on the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites, indicate that harbour seal usage is relatively low in and around the Norfolk Vanguard offshore project area and higher along the coast (Figure 12.3; Russell *et al.*, 2017).

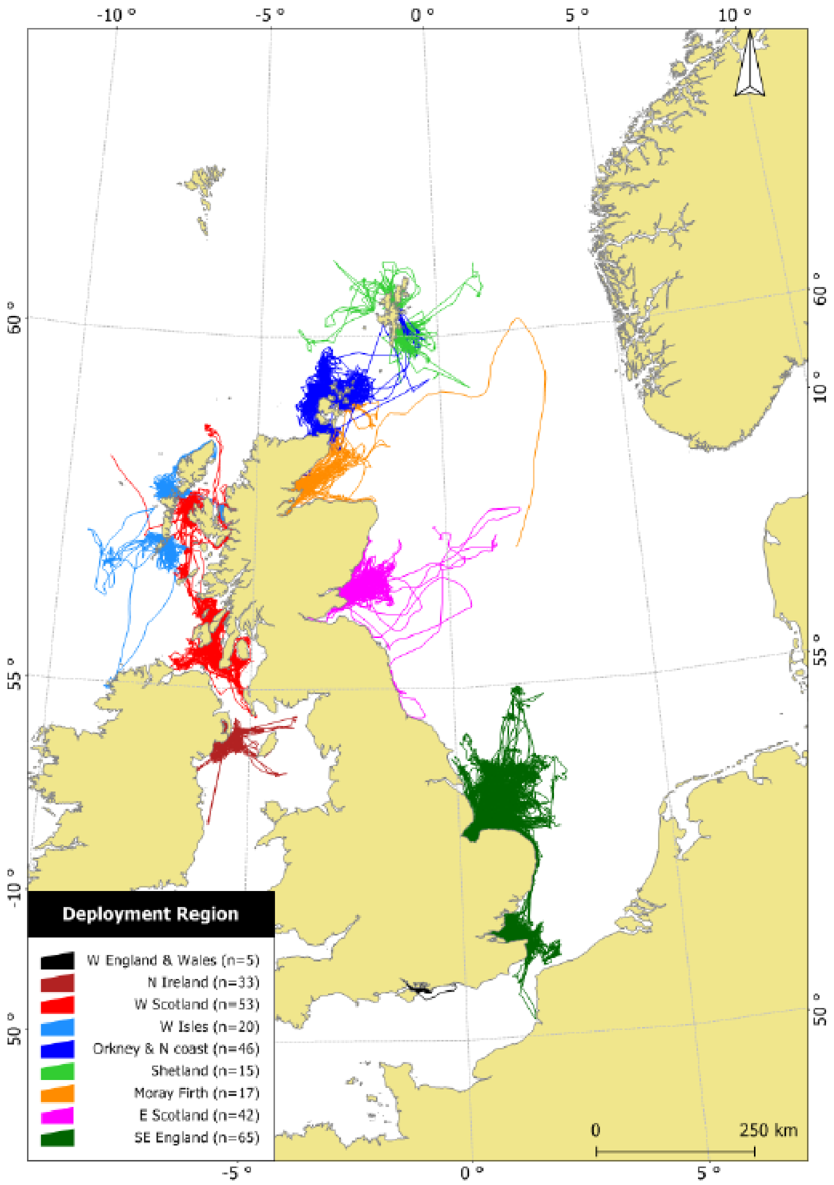


Plate 12.8 Telemetry tracks by deployment region for harbour seals aged one year or over (Source: Russell and McConnell, 2014)

12.6.2.2.2 Haul-out sites

273. Harbour seal come ashore in sheltered waters, typically on sandbanks and in estuaries, but also in rocky areas. Harbour seal regularly haul-out on land in a pattern that is often related to the tidal cycle (SCOS, 2017).

274. Harbour seal give birth to their pups in June and July and pups can swim almost immediately after birth (SCOS, 2017). Harbour seals moult in August and spend a higher proportion of their time on land during the moult than at other times (SCOS, 2017).

275. As previously discussed, NV West is located approximately 47km offshore (at the closest point). There are principal harbour seal haul-out sites at Scroby Sands which

is approximately 47km from the site, at Blakeney Point which is approximately 88km from the site and The Wash, approximately 79km from the Norfolk Vanguard OWF sites (Figure 12.4). The main breeding site for harbour seal on the east coast of England is in The Wash (SCOS, 2017).

276. As previously discussed, the Happisburgh South landfall location is approximately 11km from the Horsey seal haul-out site to the south and 43km from the Blakeney Point haul-out site to the north. These are the closest haul-out sites to the landfall location. The closest point of the Wash and North Norfolk SAC boundary (in which The Wash haul-out sites are located) is 33km from the landfall site (Figure 12.4).

12.6.2.2.3 Diet and foraging

277. Harbour seals normally feed within 40-50 km around their haul out sites. Tracking studies have shown that harbour seal typically travel 50-100km offshore and can travel 200km between haul-out sites (Lowry *et al*., 2001; Sharples *et al*., 2012). Harbour seal exhibit relative short foraging trips from their haul out sites. The range of these trips does vary depending on the surrounding marine habitat (e.g. 25km on the west of Scotland (Cunningham *et al*., 2009); 30km-45km in the Moray Firth (Tollit *et al*., 1998; Thompson and Miller, 1990). However, data from The Wash (from 2003- 2005) suggest that harbour seal in this area travel further, and repeatedly forage between 75km and 120km offshore (with one seal travelling 220km; Sharples *et al*., 2008). Telemetry studies indicate that the tracks of tagged harbour seals have a more coastal distribution than grey seals and do not travel as far from haul-outs (Plate 12.8; Russell and McConnell, 2014).

278. Harbour seal take a wide variety of prey including sandeels, gadoids, herring and sprat, flatfish and cephalopods. Diet varies seasonally and regionally, prey diversity and diet quality also showed some regional and seasonal variation (SCOS, 2017). It is estimated harbour seals eat 3-5 kg per adult seal per day depending on the prey species (SCOS, 2017).

12.6.2.2.4 Abundance and density estimates

279. Harbour seals are counted while they are on land during their August moult, giving a minimum estimate of population size (SCOS, 2017). Combining the most recent counts (2011-2015) gives a total of 31,300 counted in the UK. Scaling this by the estimated proportion hauled out (0.72 (95% CI = 0.54-0.88)) produces an estimated total population for the UK in 2015 of 43,500 harbour seal (approximate 95% CI = 35,600-58,000; SCOS, 2016).

280. Approximately 30% of European harbour seal are found in the UK; this proportion has declined from approximately 40% in 2002 (SCOS, 2017).

Management units

281. The most recent August counts (2016) of harbour seal at haul-out sites in the south-east England MU provides an estimated abundance of 5,061 harbour seal (SCOS, 2017). This includes 369 harbour seals at Donna Nook, 3,377 harbour seals at The Wash, 424 harbour seals at Blakeney Point, 198 at Scroby Sands and 694 along the Essex and Kent coast (SCOS, 2017).

282. Harbour seal are also routinely surveyed in the Wadden Sea, as part of the TSEG coordinated aerial surveys in Denmark, Germany and the Netherlands. The estimate for the total Wadden Sea harbour seal population, including seals in the water during the survey, in 2017 was estimated to be 38,100 (TSEG, 2017b).

Seal density maps

283. Table 12.19 shows the harbour seal density estimates for Norfolk Vanguard which have been calculated from the 5km x 5km cells of the SMRU harbour seal at sea usage maps (Russell *et al*., 2017) based on the area of overlap with Norfolk Vanguard (Figure 12.3).

Table 12.19 Harbour seal density estimates (based on Russell *et al*., 2017)

Density Estimate	Individuals per km^2				
	NV Offshore Cable	NV West	NV East	NV OWF sites	NV Offshore Project Area
Lower at-sea	0.003	0.00005	0.00004	0.00005	0.0009
Mean at-sea	0.05	0.0001	0.00007	0.00009	0.02
Upper at-sea	0.10	0.0001	0.0001	0.0001	0.03

284. Within the offshore wind farm sites (592km^2) the upper at-sea density of harbour seal is estimated to be 0.0001/km^2. Within the offshore cable corridor area (237km^2) the upper at-sea density of harbour seal is estimated to be 0.1/km^2.

East Anglia Zone surveys

285. Aerial surveys conducted for the East Anglia Zone, did not record any observations of seals (EAOW, 2012c) neither did aerial surveys at the East Anglia ONE site. However, during boat based surveys, three harbour seal were recorded at the East Anglia ONE site, suggesting that there is low usage of the East Anglia ONE site (EAOW, 2012b).

286. Aerial surveys conducted for East Anglia THREE (September 2011 to August 2013) consisted of the East Anglia THREE site and 4km buffer. As outlined for grey seal, only two unidentified seals were recorded during East Anglia THREE surveys (EATL, 2015). The results of the East Anglia THREE aerial surveys support the tagging data and suggest that there is low usage of the former East Anglia Zone.

Norfolk Vanguard site specific surveys

287. The total number of seal species recorded during the aerial surveys for NV East, including the EA4 surveys, from March 2012 to April 2016 (32 months) for NV East OWF and 4km buffer was five seals, these were not identified to species (Table 12.17).

288. The total number of seal species recorded during the aerial surveys for NV West from September 2015 to February 2017 for NV West and 4km buffer was four seals, none were identified as harbour seal (Table 12.18).

289. As sightings data was too low within the Norfolk Vanguard OWF sites to determine site specific density estimates, the SMRU seals at-sea density data (Table 12.19; Russell *et al*., 2017) will be used as agreed with the marine mammal ETG (Table 12.4).

12.6.2.2.5 Reference population for assessment

290. In accordance with the approach agreed with the marine mammal ETG (Table 12.4), the reference population for harbour seal will incorporate the south-east England MU and the Waddenzee region.

291. The telemetry studies outlined in sections 12.6.2.2.1 and 12.6.2.2.3 (Plate 12.8), justifies the inclusion of UK south-east England MU and the Waddenzee region in the reference population for this assessment.

292. The UK harbour seal counts are based on surveys conducted in August during the moult period and the Waddenzee count is based on harbour seal in June during the pupping season (TSEG, 2017b). Given that harbour seal in the UK also give birth to their pups in June and July (SCOS, 2017), there is unlikely to be double counting of seals during these surveys.

293. The reference population is therefore based on the following most recent counts:

- South-east England MU = 5,061 harbour seal (SCOS 2017); and
- The Waddenzee region = 38,100 harbour seal (TSEG 2017b).

294. The total harbour seal reference population for the assessment is therefore 43,161. In addition, consideration is also given to the potential impacts on the south-east England MU of 5,061 harbour seal.

12.6.2.3 Designated sites and conservation importance for pinnipeds

295. In England and Wales, seals are protected under the Conservation of Seals Act 1970. The Conservation of Seals Act prohibits taking seals during a close season (01/09 to 31/12 for grey seals and 01/06 to 31/08 for harbour seals) except under licence

issued by the Marine Management Organisation. The Act also allows for specific Conservation Orders to extend the close season to protect vulnerable populations. Under this order, there is year round protection to grey and harbour seals on the east coast of England (SCOS, 2017).

296. Both grey and harbour seals are listed in Annex II of the EU Habitats Directive, requiring specific Special Areas of Conservation (SAC) to be designated for their protection.

12.6.2.3.1 Grey seal

297. The HRA screening (Royal HaskoningDHV, 2017c) initially considered a total of 64 European designated sites where grey seal is a qualifying feature and which could have theoretical connectivity with Norfolk Vanguard based upon distance from the site. This list was refined based upon field data to a list of 24 sites with potential connectivity, which was then assessed in terms of the potential for Likely Significant Effect (LSE) of the project. Based upon this process, all sites for grey seal, with the exception of the Humber Estuary SAC, were screened out from further assessment in the HRA (see HRA Screening, Appendix 5.1 of the Information for the Habitats Regulations Assessment; Royal HaskoningDHV, 2017c (documents reference 5.3)).

298. The Humber is the second-largest coastal plain estuary in the UK, and the largest coastal plain estuary on the east coast of Britain. Grey seal (Annex II species) are present as a qualifying feature, but not a primary reason for site selection (JNCC, 2017c).

299. The Humber Estuary SAC is located 150km from Norfolk Vanguard OWF sites and 112km from the offshore cable corridor (at closest point).

300. Donna Nook is located in the Humber Estuary SAC and the most recent August count at the site in 2016 was 3,964 grey seals (SCOS, 2017). This will be taken into account in the assessment for the HRA.

301. The reference population for grey seal that encompasses the Humber Estuary SAC is the south-east England MU, although the SAC is located close to the north-east MU (IAMMWG, 2013). The latest grey seal counts from the south-east England MU in August 2016 was 6,085 (SCOS, 2017). The reference population to be used for context in the assessments for the HRA for the Humber Estuary SAC will be the south-east England MU of 6,085 grey seal.

302. As outlined in section 12.6.2.1.2, while grey seal are not currently a qualifying feature at the Wash and North Norfolk SAC (which includes Blakeney Point) or Winterton-Horsey Dunes SAC, it is recognised that these sites are important for the

population, as breeding, moulting and haul-out sites. Therefore, in the assessments for the HRA, consideration will be given to grey seal as part of the Wash and North Norfolk SAC and Winterton-Horsey Dunes SAC, to determine if there is the potential for any disturbance of seals hauled out at these sites, taking into account the most recent counts at these sites.

12.6.2.3.2 Harbour seal

303. The HRA screening (Royal HaskoningDHV, 2017c) initially considered a total of 23 European designated sites where harbour seal is a qualifying feature and which could have theoretical connectivity with Norfolk Vanguard based upon distance from the site. This list was refined based upon field data to a list of 11 sites with potential connectivity which was then assessed in terms of the potential for LSE of the project. Based upon this process, all sites for harbour seal, with the exception of the Wash and North Norfolk Coast SAC, were screened out from further assessment in the HRA (see HRA Screening, Appendix 5.1 of Report to inform the HRA (document reference 5.3); Royal HaskoningDHV, 2017c).

304. The Wash, on the east coast of England, is the largest embayment in the UK. The extensive intertidal flats here and on the North Norfolk Coast provide ideal conditions for harbour seal breeding and hauling-out. Harbour seal (Annex II species) are a primary reason for selection of this site (JNCC, 2017d).

305. The Wash and North Norfolk Coast SAC is located approximately 82km from NV West and 33km from the offshore cable corridor.

306. The mean harbour seal count for the Wash in 2016 was 3,377 (SCOS, 2017). This will be taken into account in the assessment for the HRA. The reference population for harbour seal that encompasses the Wash and North Norfolk Coast SAC is the south-east England MU. The reference population proposed to be used for context in the assessments for the HRA of the Wash and North Norfolk Coast SAC will be the south-east England MU of 5,061 harbour seal (SCOS, 2017).

12.6.3 Summary of Marine Mammal Receptors and Reference Populations

307. Table 12.20 and Table 12.21 provide a summary of the reference populations and the density estimates for the marine mammal species being taken forward for the impact assessment.

308. During the impact assessment, the magnitude of impacts will be put in context against these reference populations (see Table 12.7 for definitions of magnitude).

Table 12.20 Summary of marine mammal reference populations used in the impact assessment

Species	Reference population Extent	Year of estimate	Size	Data source
Harbour porpoise	North MU	2016	**345,373** (CV = 0.18; 95% CI = 246,526-495,752)	SCANS-III (Hammond *et al.*, 2017)
	Southern North Sea cSAC	2016	Area = 36,951km^2; winter area = 12,697km^2; and summer area = 27,018km^2. [SNS cSAC supports an estimated 29,384 harbour porpoise - additional assessment in Appendix 12.4]	JNCC (2017b) SCANS-III (Hammond et al., 2017)
Grey seal	South-east England MU; North-east England MU; East coast of Scotland MU; & Waddenzee population	2016 2016 2016 2017	6,085 + 6,948 + 3,812 + 5,445 = **22,290**	SCOS (2017) and TSEG (2017a)
	South-east England MU	2016	**6,085**	SCOS (2017)
Harbour seal	South-east England MU; and Waddenzee population	2016 2017	5,061 + 38,100 = **43,161**	SCOS (20176) and TSEG (2017b)
	South-east England MU	2016	**5,061**	SCOS (2017)

Table 12.21 Summary of marine mammal density estimates used in the impact assessment

Species	Density estimate Number of individuals per km^2	Data source
Harbour porpoise	1.26/km^2 for NV East 0.79/km^2 for NV West based on mean annual density estimate of highest monthly counts and seasonal correction factors of harbour porpoise counts combined with in unidentified dolphin/porpoise	Site specific surveys (*Appendix 12.1*)
	0.888/km^2	SCANS-III survey block O* (Hammond *et al.*, 2017)
Grey seal	0.002/km^2 for offshore wind farm sites 0.16/km^2 for offshore cable corridor area	SMRU seal at-sea usage maps (Russell *et al.*, 2017)
Harbour seal	0.0001/km^2 for offshore wind farm sites 0.1/km^2 for offshore cable corridor area	SMRU seal at-sea usage maps (Russell *et al.*, 2017)

*Norfolk Vanguard East is located in SCANS-III survey block L; Norfolk Vanguard West is located in both SCANS-III survey block L and survey block O; therefore, the maximum density from survey block O has been included.

12.6.4 Anticipated Trends in Baseline Conditions

309. The existing baseline conditions for marine mammals within the study area (described in sections 12.6.1 and 12.6.2) are considered to be relatively stable. The baseline environment of the Southern North Sea has been influenced by the oil and gas industry since the 1960s, fishing by various methods for hundreds of years and the construction and operation of offshore wind farms for over ten years (Kentish Flats in 2005; Lynn and Inner Dowsing in 2009). The baseline will continue to evolve as a result of global trends which include the effects of climate change.

310. For harbour porpoise in the North Sea the latest SCANS-III survey results show no evidence for trends in abundance since the mid-1990s (Hammond et al., 2017). Despite no overall change in population size, large scale changes in the distribution of harbour porpoise were observed between SCANS-I in 1994 and SCANS-II in 2005, with the main concentration shifting from North eastern UK and Denmark to the southern North Sea. Such large scale changes in the distribution of harbour porpoise are likely the result of changes to the availability of principal prey within the North Sea (SCANS-II, 2008).

311. The number of grey seal pups throughout Britain has grown steadily since the 1960s when records began and there is clear evidence that the population growth is levelling off in all areas, except the central and southern North Sea where growth rates remain high (SCOS, 2017). Pup production at colonies in the North Sea increased rapidly up to 2014. The majority of the increase up to 2014 was due to the continued rapid expansion of newer colonies on the mainland coasts in Berwickshire, Lincolnshire, Norfolk and Suffolk (SCOS, 2017). The 2015 and 2016 counts suggest a much lower annual increase for the east coast of England mainland colonies, with the largest colony at Blakeney showing a slight decrease after 12 years of extremely rapid increase (SCOS, 2017). At the colonies on the mainland east coast of England and especially in the southern North Sea, the rates of increase in pup production from 2010 to 2015 have been extremely high, suggesting that there must have been some immigration from colonies further north (SCOS, 2017).

312. Overall, the UK population of harbour seal has increased since the late 2000s and is close to the 1990s level (SCOS, 2017). However, there are significant differences in the population dynamics between regions, for example there have been general declines in counts of harbour seals in several regions around Scotland but the declines are not universal, with some populations either stable or increasing. Counts for the East coast of England appear stable, although the 2016 count was approximately 10% higher than in 2015, driven mainly by a doubling of the count from Essex and Kent (SCOS, 2017). The harbour seal population along the east coast of England (mainly in The Wash) was reduced by 52% following the 1988 phocine

distemper virus (PDV) epidemic. A second epidemic in 2002 resulted in a decline of 22% in The Wash, but had limited impact elsewhere in Britain. Counts in the Wash and eastern England did not demonstrate any immediate recovery from the 2002 epidemic and continued to decline until 2006. The counts increased rapidly from 2006 to 2012 but have remained relatively constant since (SCOS, 2017). In contrast, the adjacent European colonies in the Wadden Sea experienced continuous rapid growth after the epidemic, but again, the counts over the last five years suggest that the rate of increase has slowed dramatically (SCOS, 2017).

12.7 Potential Impacts

313. The impacts and the assessment methodologies during the construction, operation and decommissioning of Norfolk Vanguard have been agreed in consultation with the marine mammal ETG (Table 12.4).

314. The potential impacts during construction assessed for marine mammals (section 12.7.3) are:

- Physical and auditory injury resulting from the underwater noise associated with clearance of unexploded ordnance (UXO);
- Behavioural impacts resulting from the underwater noise associated with clearance of unexploded ordnance (UXO);
- Physical and auditory injury resulting from underwater noise during piling;
- Behavioural impacts resulting from underwater noise during piling;
- Behavioural impacts resulting from underwater noise during other construction activities, for example, seabed preparation, rock dumping and cable installation;
- Barrier effects as a result of underwater noise associated with activities above;
- Impacts resulting from the deployment of construction vessels including:
  - Underwater noise and disturbance from vessels;
  - Vessel interaction (collision risk);
  - Disturbance at seal haul-out sites;
- Changes to prey resource; and
- Changes to water quality.

315. The potential impacts during operation and maintenance assessed for marine mammals (section 12.7.5) are:

- Behavioural impacts resulting from the underwater noise associated with operational turbines;
- Behavioural impacts resulting from the underwater noise associated with maintenance activities, such as any additional rock dumping and cable re-burial;

- Impacts resulting from the deployment of maintenance vessels including:
    - Underwater noise and disturbance from vessels;
    - Vessel interaction (collision risk);
    - Disturbance at seal haul-out sites;
- Entanglement in floating foundations; and
- Changes to prey resource.

316. The potential impacts during decommissioning assessed for marine mammals (section 12.7.6) are:

- Physical and auditory injury resulting from the noise associated with foundation removal (e.g. cutting);
- Behavioural impacts resulting from the noise associated with foundation removal (e.g. cutting);
- Barrier effects as a result of underwater noise associated with activities above;
- Behavioural impacts resulting from the deployment of construction vessels. Impacts assessed are those associated with:
    - Underwater noise and disturbance from vessels;
    - Vessel interaction (collision risk);
    - Disturbance at seal haul-out sites;
- Changes to prey resource; and
- Changes to water quality.

317. Section 12.7.1 summarises the embedded mitigation relevant to marine mammals, with any further mitigation, if required, outlined in the relevant impact section. Section 12.7.2 outlines the worst-case scenarios used in the assessment of the potential impacts on marine mammals.

12.7.1 Mitigation

12.7.1.1 Embedded mitigation

318. Norfolk Vanguard Limited has committed to a number of techniques and engineering designs/modifications inherent as part of the project, during the pre-application phase, in order to avoid a number of impacts or reduce impacts as far as possible. Embedding mitigation into the project design is a type of primary mitigation and is an inherent aspect of the EIA process.

319. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project Description, Chapter 4 Site Selection and Assessment of Alternatives) including

engineering requirements, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

320. A number of embedded mitigation measures have been incorporated into the design of the development to prevent or reduce any significant adverse effects where possible.

321. Where possible, the embedded mitigation has been taken into account in each relevant impact assessment when assessing the potential magnitude of the impact.

322. In addition to embedded mitigation, if further mitigation is required and possible, (i.e. those measures to prevent or reduce any remaining significant adverse effects) these are discussed in the relevant impact sections and the post-mitigation residual impact significance is provided.

12.7.1.1.1 Reduction of turbine numbers

323. Following PEIR, Norfolk Vanguard Limited has reduced the maximum number of turbines from 257 to 200, while maintaining the maximum generating capacity of 1800MW by committing to using 9MW to 20MW turbines.

324. This reduction in the maximum number of turbines reduces the number of foundations that could require piling, thereby reducing the overall potential underwater impacts on marine mammals. The reduction in the maximum number of turbines also reduces the potential maximum duration for turbine foundation installation, therefore again reducing the overall potential underwater impacts on marine mammals. In addition, the reduction in the maximum number of turbines would also reduce the physical footprint and any potential habitat loss for prey species.

12.7.1.1.2 Underwater noise

325. Norfolk Vanguard Limited has committed to the following embedded mitigation which has already been incorporated into the project design in order to reduce potential effects on marine mammals:

- The use of a soft-start and ramp-up protocol:
    - o Each piling event would commence with a soft-start for a minimum of 10 minutes at 10% of the maximum hammer energy followed by a gradual ramp-up for at least 20 minutes to the maximum hammer energy (although maximum hammer energy is only likely to be required at a few of the piling installation locations).
    - o This minimum 30 minute soft-start and ramp-up duration is more precautionary than the current JNCC (2010a) guidance, which recommends

that the soft-start and ramp-up period duration should be a period of not less than 20 minutes.

- o During the 30 minutes for the soft-start and ramp-up it is estimated that animals would move over 2.7km away from the piling location, based upon a precautionary average marine mammal swimming speed of 1.5m/s (Otani *et al*., 2000). For a precautionary swim speed of 1.8m/s which is more representative of a fleeing animal (e.g. Kastelein *et al*., 2018 recorded harbour porpoise swimming speeds of 1.97m/s during playbacks of pile driving sounds), the distance covered would be 3.2km. However, as a precautionary approach the assessments have been based on the average marine mammal swimming speed of 1.5m/s.
  - During the minimum 10 minute soft-start it is estimated that marine mammals would move at least 0.9km from the piling location.
  - During the 20 minute ramp-up it is estimated that marine mammals would move at least 1.8km.

12.7.1.1.3 Water quality

326. As outlined in Chapter 9 Marine Water and Sediment Quality, Norfolk Vanguard Limited is committed to the use of best practice techniques and due diligence regarding the potential for pollution throughout all construction, operation, maintenance and decommissioning activities. A draft Project Environmental Management Plan (PEMP) (document reference 8.14) has been submitted with the DCO application. This includes, but is not limited to, the following mitigation measures embedded into the design:

- Oils and lubricants used in the wind turbines would be biodegradable where possible and all chemicals would be certified to the relevant standard.
- All wind turbines would incorporate appropriate provisions to retain spilled fluids within the nacelle and tower. In addition, converter and collector stations would be designed with a self-contained bund to contain any spills and prevent discharges to the environment.
- Best practice procedures would be put in place when transferring oil or fuel between converter or collector stations and service vessels.
- Appropriate spill plan procedures would also be implemented in order to appropriately manage any unexpected discharge into the marine environment, these would be included in a Marine Pollution Contingency Plan (MPCP) to be agreed post-consent. To avoid discharge or spillage of oils it is anticipated that the transformers would be filled for their operational life and would not need interim oil changes.

- Inclusion of control measures such as the requirement to carry spill kits and the requirement for vessel personnel to undergo training to ensure requirements of the PEMP are understood and communicated.
- All work practices and vessels will adhere to the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78; specifically Annex 1 Regulations for the prevention of pollution by oil concerning machine waters, bilge waters and deck drainage and Annex IV Regulations for the prevention of pollution by sewage from ships concerning black and grey waters.

12.7.1.2 Further Mitigation

12.7.1.2.1 MMMP for piling

327. The MMMP for piling will be developed in the pre-construction period and based upon best available information and methodologies. A draft MMMP for piling (document reference 8.13) is submitted with the DCO Application. The MMMP for piling will be developed in consultation with the relevant SNCBs and the MMO, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury (PTS) to marine mammals during all piling operations. This will include details of the embedded mitigation, for the soft-start and ramp-up, as well as details of the mitigation zone and additional mitigation measures required in order to minimise potential impacts of any physical or permanent auditory injury (PTS), for example, the activation of acoustic deterrent devices (ADDs) prior to the soft-start.

328. A mitigation zone, based on instantaneous PTS and cumulative PTS impact ranges, will be established. Mitigation measures would aim to remove marine mammals from the mitigation zone prior to the start of piling to reduce the risk of any physical or auditory injury.

329. The methods for achieving the mitigation zone would be agreed with the MMO in consultation with the relevant SNCBs and secured as commitments within the MMMP for piling.

12.7.1.2.2 MMMP for UXO clearance

330. A detailed MMMP will also be prepared in the pre-construction phase for UXO clearance. The MMMP for UXO clearance will ensure there are adequate mitigation measures to minimise the risk of any physical or permanent auditory injury to marine mammals as a result of UXO clearance. The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information on the UXO clearance which could be required and the most suitable

mitigation measures, based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and the MMO. See section 12.7.4.1.6.

12.7.1.2.3 In Principle Site Integrity Plan

331. In addition to the MMMPs, a Norfolk Vanguard Southern North Sea cSAC Site Integrity Plan (SIP) will be developed and an in principle SIP (document reference 8.17) is provided with the DCO application. The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SNS cSAC.

12.7.2 Worst-Case Scenarios used in Assessment

332. The offshore project area consists of:

- The offshore cable corridor with landfall at Happisburgh South;
- Norfolk Vanguard West (NV West); and
- Norfolk Vanguard East (NV East).

333. The realistic worst-case scenario for each category of potential impact has been determined. For this assessment, the realistic worst-case scenario involves consideration of both the relative timing, as well as the potential worst-case parameters that define the project design envelope for Norfolk Vanguard.

334. Norfolk Vanguard Limited is currently considering constructing the project in either a single phase or two phases (up to a maximum of 1,800MW). The layout of the wind turbines will be defined post-consent, but would be based on the following maxima:

- 1,800MW in NV East and 0MW in NV West; or
- 0MW in NV East and 1,800MW in NV West.

335. Any other potential layouts that are considered up to a maximum of 1800MW (e.g. 1,200MW in NV West and 600MW in NV East; 600MW in NV West and 1,200MW in NV East; or 900MW in NV West and 900MW in NV East) lie within the envelope of these scenarios.

336. The infrastructure would be the same for each phasing scenario and therefore the total time for construction activities (e.g. active piling time) would be the same.

337. Consideration is given to the impacts on marine mammals over the full construction window which is expected to be up to approximately four years for the full 1800MW capacity, regardless of the phasing scenario (Table 12.22 and Table 12.23).

338. Within Norfolk Vanguard, several different sizes of wind turbine are being considered in the range of 9MW to 20MW. In order to achieve the maximum 1,800MW export capacity, there would be between:

- 90 x 20MW wind turbines; and
- 200 x 9MW wind turbines.

339. The worst-case scenario for each effect is outlined in Table 12.24.

340. In addition, up to two offshore electrical platforms, two accommodation platforms, two meteorological masts, two LiDAR platforms and two wave buoys, plus offshore cables are considered as part of the worst-case scenario.

341. A range of foundation options is currently being considered, these include:

- For wind turbines these are:
  - Monopiles (piled));
  - quadropod or tripod jackets (either pin-piles or suction caissons);
  - gravity base structure (GBS);
  - suction caissons; and
  - tension leg floating platforms.
- For the offshore electrical platforms these are GBS, monopile, pin-pile or suction caisson;
- For the accommodation platforms these area monopile, pin-pile or suction caisson;
- For the met masts the options are GBS, monopile or pin-pile for met masts; and
- For LiDAR (Light Detection and Ranging for remote sensing) platforms the foundations could be floating with anchors or monopile.

342. The worst-case scenario for each parameter that could have a potential impact on marine mammals is outline in Table 12.24.

343. Full details of the range of development options being considered are provided within Chapter 5 Project Description. Only those design parameters with the potential to influence the level of impact on marine mammals are included in Table 12.24.

344. The realistic worst-case scenarios identified here also apply to the Cumulative Impact Assessment (CIA). When the worst-case scenarios for the project in isolation do not result in the worst-case for cumulative impacts, this is addressed within the cumulative section of this chapter (see section 12.8).

Table 12.22 Indicative Norfolk Vanguard construction programme – single phase

		2024				2025				2026				2027				2028			
Indicative Programme	**Approximate duration**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Foundation installation	20 months																				
Array & interconnector cable installation	19 months																				
Export cable installation	19 months																				
Wind turbine installation	20 months																				
Total construction works	23 months																				

Table 12.23 Indicative Norfolk Vanguard construction programme – two phase

		2024				2025				2026				2027				2028			
Indicative Programme	**Approximate duration**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Foundation installation	2 x 8 months																				
Array & interconnector cable installation	2 x 7 months																				
Export cable installation	2 x 7 months																				
Wind turbine installation	2 x 8 months																				
Total construction works	2 x 12 months																				

Table 12.24 Worst-case parameters for marine mammal receptors

Impact	Parameter	Maximum worst-case	Rationale
Construction			
Underwater noise from UXO clearance	Number of UXO	• 9 in NV East • 5 in NV West • 28 in offshore cable corridor Total = 42	Estimated worst-case of nine clearance operations in NV East, five in NV West and 28 in the offshore cable corridor based on initial geophysical data (Fugro, 2016) but numbers will be determined by a pre-construction UXO survey.
	Type and size of UXO	• German LMB (GC) Ground Mine (up to 700kg NEQ)) • British A Mk6 Ground Mine (up to 430 kg NEQ) • German E series buoyant mine (up to 150kg NEQ)) • British MK14 Buoyant mine (up to 227kg NEQ) • 250lb HE Bomb (up to 55kg NEQ)) • 500lb HE Bomb (up to 120kg NEQ)) • 1000lb HE Bomb (up to 250kg NEQ))	A detailed UXO survey would be completed prior to construction. The type, size (net explosive quantities (NEQ)) and number of possible detonations and duration of UXO clearance operations is therefore not known at this stage
Underwater noise from pile driving (alternative foundation types are also considered but do not represent the worst-case scenario for underwater noise)	Number of wind turbines	• 200 (9MW turbines) • 90 (20MW turbines)	The maximum number of piled foundations would represent the **temporal** worst-case scenario. The maximum predicted impact range for underwater noise for piled foundations would represent the **spatial** worst-case scenario. The maximum potential disturbance range is 26km, for all sizes piles and hammer energies, based on current SNCB guidance.
	Number of other offshore platforms	• 2 x offshore electrical platforms • 2 x Met masts • 2 x LiDAR • 2 x Accommodation Total = 8	The maximum number of offshore platforms represents the worst-case scenario in addition to turbine scenarios above.
	Proportion of foundations that are piled	100%	The maximum proportion of piled foundations represents the worst-case scenario for underwater noise.

Impact	Parameter	Maximum worst-case	Rationale
	Number of piles per foundation	• 1 (monopile) • 3 (tripod with pin-piles of the same diameter as the quadropod and therefore this will not be the worst-case scenario) • 4 (quadropod with pin-piles or tension leg floating platform with up to 4 anchors) • 6 legged jacket – offshore electrical platforms and accommodation platforms only	The maximum number of piles would represent the **temporal** worst-case scenario however the maximum number of the largest piles (monopiles) would represent the greatest **spatial** impact.
	Maximum number of piles - Wind turbines	200 x 4 (9MW quadropod) Total = 800	The 9MW quadropod will represent the worst-case temporal impact due to having the greatest number of piles.
	Maximum number of piles - Other offshore platforms	• 2 x offshore electrical platforms with 6 piles = 12 • 2 x Met masts quadropod = 8 • 2 x LiDAR monopile = 2 • 2 x Accommodation platform with 6 piles = 12 Total = 34	Assumes a worst-case of 6 pin-piles/piled anchors per offshore electrical platforms and accommodation platform.
	Total number of piled foundations	834	The maximum number of piles would represent the temporal worst-case scenario.
	Hammer energies	Maximum hammer energy: • 2,700kJ (9MW-20MW pin-pile) • 5,000kJ (20MW monopile) Starting hammer energies of 10% will be used followed by ramp-up to the maximum hammer energy.	5,000kJ hammer energy represents the worst-case scenario for the noise impact at any one time. Consideration will also be given to the increased temporal impact associated with the 9MW quadropod foundations with pin-piles.

Impact	Parameter	Maximum worst-case	Rationale
	Pile diameter	• 10m (9MW monopile) • 3m (9MW pin-pile) • 15m (20MW monopile) • 5m (20MW pin-pile)	The largest pile (20MW monopile) requires the maximum hammer energy and will represent the worst-case spatial impact.
	Total piling time – per turbine foundation (providing allowance for soft-start, ramp-up and issues such as low blow rate, refusal)	• 6hrs per pile (9MW monopile) x 200 piles = 1,200 hours (4,000kJ hammer) • 1.5hrs per pin-pile (9MW quadropod) x 800 piles = 1,200 hours (2,700kJ hammer) • 6hrs per pile (20MW monopile) x 90 piles = 540 hours (5,000kJ hammer) • 3hrs per pin-pile (20MW quadropod) x 360 piles = 1,080 hours (2,700kJ hammer)	The maximum piling duration of 1,200 hours associated with 9MW monopile or 9MW quadropod represents the temporal worst-case scenario.
	Total piling time – per platform foundation (providing allowance for soft-start, ramp-up and issues such as low blow rate, refusal)	• 1.5hrs per pile (six pin-piles for offshore electrical platforms) x 12 piles = 18 hours • 1.5hrs (six pin-piles for accommodation platforms) x 12 piles = 18 hours • 1.5hrs per pile (Met masts quadropod) x 8 = 12 hours • 6hrs per pile (LiDAR monopiles) x 2 = 12 hours • Total = 60 hours	Assumes a worst-case of 6 pin-piles/piled anchors per offshore electrical platforms and accommodation platform.
	Foundation installation period within construction period	• Single phase = 20 months • Two phase = 2 x 8 months	This is an indicative period within which foundation installation, including piling is anticipated to occur.
	Number of concurrent piling events	2	The maximum number of concurrent piling events represents the worst case spatial impact.

Impact	Parameter	Maximum worst-case	Rationale
	Min. spacing between piling vessels	680m	Based on the closest turbine spacing.
	Max. spacing between piling vessels	Approximately 27km	Based on the limits of the Offshore Wind Farm (OWF) site (including NV East and NV West) boundaries. The maximum spacing represents the worst-case spatial impact.
Underwater noise from seabed preparation, rock dumping and cable installation	Cable installation methods	• Surface laid with cable protection if burial is not possible; • Ploughing; • Jetting; • Dredging; • Mass flow excavation; and • Trenching.	
	Array cable length	600km	Maximum potential for underwater noise impacts.
	Max no. of array cable laying vessels on site	3	
	Max no. of export cable laying vessels on site	3	
	Indicative duration of cable installation	• Single phase = 19 months • Two phase = 2 x 7 months = 14 months	19 months represents the indicative maximum cable installation duration.
	Interconnection cable length	Up to 150km length. Based on turbine capacity being split between NV East and NV West	Maximum potential for underwater noise impacts during installation.
	Total export cable length	4 x approximately 100km cables based on all capacity being in NV East.	

Impact	Parameter	Maximum worst-case	Rationale
		Laid as pairs with a total of 2 trenches, up to 200km trench length.	
Vessels • Underwater noise and disturbance from vessels • Collision risk • Disturbance at seal haul-out sites	Maximum number of vessels on site at any one time during construction	Maximum = 57	Maximum potential for disturbance or collision risk.
	Indicative number of movements	Single phase = 1,180 Two phase = 590 x 2 phases = 1,180 in total	
	Vessel types	Vessel types that could be on site during construction include: • Seabed preparation vessels • Transition piece installation vessels • Scour Installation Vessels • Number of vessels engaged in foundations • WTG installation vessels • Commissioning vessels • Accommodation vessels • Inter-array cable laying vessels • Export cable laying vessels • Landfall cable installation vessels • Substation / collector station installation vessels • Other vessels	
	Port locations	Will be determined post consent. Assessment will consider Great Yarmouth, Lowestoft and Hull.	A local port on the east coast of England is likely scenario. Vessel traffic to and from port would likely become integrated in existing shipping routes.

Impact	Parameter	Maximum worst-case	Rationale
Operation and maintenance			
Underwater noise from turbines	Number of wind turbines	200 (9MW devices) 90 (20MW devices)	
	Wind turbine size	9-20MW	
Underwater noise from maintenance activities, such as any additional rock dumping and cable re-burial	Unplanned repairs and reburial of cables may be required during O&M: • Reburial of up to 20km length per export cable pair. • Reburial of 25% of array cable is estimated once every 5 years. • Two array cable repairs per year are estimated. • One interconnector repair per year is estimated. Rock dumping may be required should reburial not be possible.		Maximum potential for disturbance.
Vessels • Underwater noise and disturbance from vessels • Collision risk • Disturbance at seal haul-out sites	Number of wind farm support vessel trips per year.	440	Maximum potential for disturbance or collision risk.
Entanglement in floating foundation tension mooring lines	Diameter of Floating Structure (m)	12MW turbine = 55m 20 MW turbine = 70m	
	Minimum water penetration depth (m) of floating structure	3m	

Impact	Parameter	Maximum worst-case	Rationale
	Maximum water penetration depth (m) of floating structure	35m	
	Maximum number of anchor lines	12 (up to 4 anchors)	
	Anchor line thickness (m)	12MW turbine = 0.45m 20 MW turbine = 0.65m	
	Anchor line material	Steel	
	Anchor line length - 40m water depth (m)	20m	
	Angle of mooring line from structure to seabed	Vertical or up to 30°	
	Anchor material	Steel-reinforced-Concrete	
	Maximum movement at surface (m)	10m	
Permanent loss of sea bed habitat – changes in prey availability	Permanent footprint of offshore infrastructure.	Turbines Total worst case turbine footprint (1800MW) with scour protection, based on 90 x 20MW tension floating platform with a gravity anchor of 70 x 70m (350 x 350m with scour protection) = 11,025,000m^2. Array cable protection Up to 60km of cable protection may be required in the unlikely event that array cables cannot be buried (based on 10% of the length) resulting in a footprint of 300,000m^2 (based on protection width of 5m).	

Impact	Parameter	Maximum worst-case	Rationale
		Array cable protection at turbines 100m cable length x 5m width x 200 turbines = 100,000m^2 Array cable crossings protection 10 crossings x 100m x 10m = 10,000m^2 <u>Interconnector cable protection</u> Interconnector cable protection approaching platforms 100m cable length x 5m width x 2 platforms = 1,000m^2 Surface laid interconnector cable protection 5m width x 15,000m (10% of the length) = 75,000m^2 Interconnector cable crossings protection crossings – captured within export cable/array cable crossing total <u>Platforms and other infrastructure</u> Two offshore electrical platforms with scour protection = 35,000m^2 Two accommodation platforms with scour protection = 35,000m^2 Two met masts with scour protection = 15,708m^2 Two wave buoys = 300m^2 Two LiDAR monopiles with scour protection = 157m^2 **Total WCS footprint in the OWF sites = 11.6km^2** <u>Export cables</u> Crossings: A total of eleven crossings are required for each cable pair (up to 22 crossings) resulting in a total footprint of 22,000m^2 (based on a width of 10m and	

Impact	Parameter	Maximum worst-case	Rationale
		length of 100m of cable protection per crossing). Nearshore (within 10m depth contour): Cable protection may be required at each of the landfall HDD exit points. This would entail one mattress (6m length x 3m width x 0.3m height) plus rock dumping (5m length x 5m width x 0.5m height) at each exit point (up to two cable pairs) resulting in a footprint of $36m^2$ Unburied cables: In the unlikely event that cable burial is not possible due to hard substrate being encountered, up to 28km of additional protection resulting in a footprint of $140,000m^2$ (based on protection width of 5m). **<u>Total</u>** **WCS footprint in the offshore cable corridor = $0.16km^2$**	
Decommissioning			
Underwater noise from foundation removal (e.g. cutting)	Assumed to be as construction (with no pile driving). Assumed piles cut off below seabed level and all wind turbine components above seabed level removed. Some or all of the array cables, interconnector cables, and offshore export cables would be removed. Scour and cable protection would likely be left *in situ*.		
Vessels • Underwater noise and disturbance from vessels • Collision risk • Disturbance at seal haul-out sites	Assumed to be similar vessel types, numbers and movements to construction phase (or less).		

12.7.3 Monitoring

345. An In Principle Monitoring Plan (document 8.12), outline Marine Mammal Mitigation Protocol (MMMP) and Site Integrity Plan (SIP) is provided with the DCO application. These form the framework for developing and agreeing mitigation and monitoring measures, with the SIP focussing on reducing the potential disturbance in relation to the Southern North Sea cSAC. In order to address the overall cumulative impact, Norfolk Vanguard Limited is committed to working with SNCBs, the MMO and other developers to establish a possible strategic approach to mitigation and monitoring.

12.7.4 Potential Impacts during Construction

346. The construction scenarios which this assessment has been based on are presented within Chapter 5 Project Description. The realistic worst-case scenario on which the assessment is based for marine mammal receptors is outlined in Table 12.24.

347. Depending on the receptor, the construction of the wind farm (including wind turbines, array cables, interconnector cables and platforms) may have very different impacts in terms of type and magnitude than those impacts resulting from the construction activities in the offshore cable corridor. The impacts of the entire project are assessed as a whole, although where relevant the impacts have been assessed separately for the offshore wind farm (OWF) sites (NV East and NV West) and the offshore cable corridor. Therefore, for impacts that span both the OWF sites and the offshore cable corridor, magnitude may be discussed separately (under the same impact), however consideration is given to the combined magnitude in order to define the significance of that impact for the project overall.

12.7.4.1 Impact 1: Underwater UXO clearance

348. There is the potential requirement for underwater unexploded ordnance (UXO) clearance prior to construction. Whilst any underwater UXO that are identified would preferentially be avoided or removed from the seabed and disposed of onshore in a designated area, it is necessary to consider the requirement for underwater UXO detonation where it is deemed unsafe to retrieve the UXO from the seafloor.

349. A detailed UXO survey would be completed prior to construction. The number of possible detonations and duration of UXO clearance operations is therefore not known at this stage. However, a strategic UXO risk management assessment has been conducted for Norfolk Vanguard to determine the potential seabed effects during Explosive Ordnance Disposal (EOD), this is presented in Appendix 5.2.

350. This technical note:

- Assessed typical UXO items, likely to be recommended for high order disposal.

- Assumed that all items found are live and the maximum explosive content is present.
- Assumed that approximately 5kg donor charge will be used during the EOD phase.

351. The technical note is drawn both from practical offshore industry experience, open-source studies and principles applied by military EOD specialists.

352. The assessment indicates that the principal UXO to consider are German and British sea mines, with German High Explosive (HE) bombs, torpedoes and depth charges a lower residual background threat. In addition, there are munitions related wrecks within the area and therefore naval projectiles are also a consideration. From experience of UK North Sea developments, the presence of Allied HE bombs are considered to also be a principal UXO hazard.

353. Other items of UXO may be encountered, however the wide range of net explosive quantities (NEQ) of the items above provide a good baseline for predicting and measuring the effects of any other items that could be encountered at Norfolk Vanguard. Table 12.25 illustrates the NEQ of the potential types of UXO that may be encountered at Norfolk Vanguard.

Table 12.25 Potential UXO that could be located at Norfolk Vanguard

UXO item	Nominal NEQ (kg)	TNT Equivalent (kg)
German LMB (GC) Ground Mine (Hexanite)	700	770
British A Mk6 Ground Mine	430	525
German E series buoyant mine (Wet Gun Cotton / TNT - worst case)	150	150
British MK14 Buoyant mine	227	261
250lb HE Bomb (Amatol / TNT)	55	55
500lb HE Bomb (Amatol / TNT)	120	120
1000lb HE Bomb (Amatol / TNT)	250	150

354. When an item of UXO detonates on the seabed underwater, several effects are generated, most of which are localised at the point of detonation, such as crater formation and movement of sediment and dispersal of nutrients and contaminants. After detonation there is the rapid expansion of gaseous products known as the "bubble pulse". Once it reaches the surface, the energy of the bubble is dissipated in a plume of water and the detonation shock front rapidly attenuates at the water/air boundary. Fragmentation (that is shrapnel from the weapon casing and surrounding seabed materials) is also ejected but does not pose a significant hazard underwater for receptors more than approximately 10m away, see Appendix 5.2.

355. The effect that can impact marine mammals is the shock transmitted through the water column. The high amplitude shock waves and the attendant sound wave produced by underwater detonations have the potential to cause injury or death to marine mammals (e.g. Richardson *et al*., 1995; von Benda-Beckmann *et al*., 2015). The main potential effects of underwater explosions on an individual animal are (1) trauma (from direct or indirect blast wave effect injury) such as crushing, fracturing, haemorrhages, and rupture of body tissues caused by the blast wave, resulting in immediate or eventual mortality; (2) auditory impairment (from exposure to the acoustic wave), resulting in a temporary or permanent hearing loss such as temporary threshold shift (TTS) and permanent threshold shift (PTS); or (3) behavioural change, such as disturbance to feeding, mating, breeding, and resting. Studies of blast effects on cetaceans indicate that smaller species are at greatest risk for shock wave or blast injuries (Ketten, 2004; von Benda-Beckmann *et al*., 2015).

356. The severity of consequence of UXO detonation will depend on many variables but principally on the charge weight and its proximity to the receptor. In simple terms, the larger the UXO charge weight and the closer it is to any given receptor, the more damage it may cause, as explained in Appendix 5.2. After detonation the shock wave will expand spherically outwards and will travel in a straight line (i.e. line of sight), unless the wave is reflected, channelled or meets an intervening obstruction.

357. The shock wave from a detonation consists of an almost instantaneous rise in pressure to a peak pressure, followed by an exponential decay in pressure to the hydrostatic pressure. Initially, the velocity of the shock wave is proportional to the peak pressure but rapidly settles down to the speed of sound in water, around 1,525m/s.

358. The pressure from a shock wave, and thus the potential for impact on marine mammals depends largely on the NEQ and specific detonation velocity. Radiation and attenuation of the pressure wave depends on water depth, sediment, sea state, stratification of the water column, temperature, salinity and other variables. It is difficult to determine the precise distance at which physical injury and possible death could occur to marine mammals. However, research suggests that the shock effect on marine mammals, as air-breathers and with similar respiratory lung function, is akin to that of humans, as presented I Appendix 5.2. The current advice to Royal Navy EOD operators is to use the Diver/Swimmer minimum danger range, as outlined in Table 12.26.

Table 12.26 Royal Navy Minimum Safe Distance for Swimmers (Source: Ministry of Defence, 1988)

Charge Weight of TNT (kg)	Distance (m)
Up to 250	1,200
250-500	1,500

Charge Weight of TNT (kg)	Distance (m)
500-1,000	2,000
1,000-2,000	2,500

359. The source levels from explosive detonations are some of the largest sounds generated by anthropogenic activities and can produce source levels of 272-287 dB re1µPa@1m (0-peak), or greater (Genesis, 2011). Explosions generate low frequencies 2-1000Hz, with the main energy between 6-21Hz and have very short durations <1ms-10ms (Richardson *et al*., 1995; NRC, 2005; Genesis, 2011). The low frequency energy has the potential to travel considerable distances (Parvin *et al*., 2007).

360. The high amplitude shock waves and the attendant sound wave produced by underwater detonations have the potential to cause injury or death to marine mammals (e.g. Richardson *et al*., 1995; von Benda-Beckmann *et al*., 2015). The main potential effects of underwater explosions on an individual animal are (1) trauma (from direct or indirect blast wave effect injury) such as crushing, fracturing, haemorrhages, and rupture of body tissues caused by the blast wave, resulting in immediate or eventual mortality; (2) auditory impairment (from exposure to the acoustic wave), resulting in a temporary or permanent hearing loss such as temporary threshold shift (TTS) and permanent threshold shift (PTS); or (3) behavioural change, such as disturbance to feeding, mating, breeding, and resting. Studies of blast effects on cetaceans indicate that smaller species are at greatest risk for shock wave or blast injuries (Ketten, 2004; von Benda-Beckmann *et al*., 2015).

361. There are limited acoustic measurements for underwater explosions and there can be large differences in the noise levels, depending on the charge size, as well as water depth, bathymetry and seabed sediments at the site, which can also influence noise propagation. The water depth in which the explosion occurs has a significant influence on the effect range for a given charge mass (von Benda-Beckmann *et al*., 2015).

362. Von Benda-Beckmann *et al*. (2015) undertook an assessment of UXO clearance in the southern North Sea. In this study, charge masses ranged from 10 to 1,000kg, with most at 125 to 250kg and most detonations occurring in water depths between 20m and 30m. In the measured explosions, large differences in received levels were noticeable, with Sound Exposure Levels (SELs) on average lower near the surface than near the bottom or in the middle of the water column. In this study, the largest distance at which the peak overpressure corresponded to risk of observed ear trauma was at approximately 500m based on measured peak overpressure for a charge mass of 263kg in water depth of 26m. Beyond 1,800m the peak overpressures fell below the limit at which no ear trauma occurred for a charge mass of 263kg in water depth

of 26m. The minimum SEL measured within 2km was 191dB re 1 μPa^{2}s, which exceeded by 1 dB the SEL-based risk threshold above which PTS was considered very likely in harbour porpoise (190dB re 1 μPa^{2}s), and exceeded by 12dB, the lower limit of PTS onset in harbour porpoise (179dB re 1 μPa^{2}s). Model predictions of effect distances as a function of SEL thresholds indicated that the effect distances for the lower limit of PTS in harbour porpoise varied between hundreds of meters and 15km for the charge masses ranging from 10 to 1,000kg (von Benda-Beckmann *et al*., 2015).

12.7.4.1.1 Sensitivity

363. In this assessment all species of marine mammal are considered to have **high** sensitivity to UXO detonations if they are within the potential impact ranges for physical injury or auditory injury (PTS). Marine mammals within the potential impact area are considered to have very limited capacity to avoid such effects, and unable to recover from physical injury or auditory injury (Table 12.5).

364. The sensitivity of marine mammals to disturbance as a result of underwater UXO detonations is considered to be **medium** in this assessment as a precautionary approach. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects (Table 12.5), although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased.

365. The sensitivity of each receptor to TTS onset and flee response / likely avoidance is considered the same as the sensitivity to disturbance.

12.7.4.1.2 Underwater noise modelling

366. Predictive underwater noise modelling, see Appendix 5.4, has been undertaken to estimate the potential impact ranges for marine mammals likely to arise during UXO clearance for Norfolk Vanguard, based on the UXO that could be located at Norfolk Vanguard (Table 12.25).

367. As outlined above, a number of UXOs with a range of charge weights could be located within the boundary of the Norfolk Vanguard site. There is expected be a variety of explosive types, which will have been subject to degradation and burying over time. Two otherwise identical explosive devices are therefore likely to produce different blasts where one has spent an extended period on the sea bed.

368. A selection of explosive sizes has been considered in the estimation of the underwater noise levels produced by detonation of UXO, based on the UXO Hazard and Risk Assessment with Risk Mitigation Strategy presented in Appendix 5.2. The potential impact has been compared to up to date impact criteria in respect of marine mammals

that could be present in the area. This assessment assumes the maximum explosive charge is present.

369. The noise produced by the detonation of explosives is affected by a number of different elements, only one of which, the charge weight, can easily be factored into a calculation. In this case the charge weight is based on the equivalent weight of TNT. Many other elements relating to its situation (e.g. its design, composition, age, position, orientation, whether it is covered by sediment) are unknown and cannot be directly considered in an assessment. This leads to a high degree of uncertainty in the estimation of the source noise level (i.e. the noise level at the position of the UXO). A worst-case estimation has therefore been used for calculations, assuming that the UXO to be detonated is not buried, degraded or subject to any other significant attenuation.

370. The consequence of this is that the noise levels produced, particularly by the larger explosives under consideration, are likely to be over-estimated as they are likely to be covered by sediment and degraded.

371. The NEQ of explosive material in the device is corrected, depending on the type of explosive material, to an equivalent quantity of TNT for the purpose of calculations (Table 12.25).

372. Estimation of the source noise level for each charge weight was carried out in accordance with the methodology of Soloway and Dahl (2014), which follows Arons (1954) and MTD (1996). These cannot take into account the range of variables noted above and thus will only provide an indication of the noise output from each detonation, assuming a freely suspended charge.

373. The attenuation of the noise as it propagates from the source location is accounted for in calculations using geometric spreading and a sound absorption coefficient, using the methodologies cited in Soloway and Dahl (2014). This calculation is used to give an indication of the range of effect, but does not take into account variable bathymetry or seabed type. However, an attenuation correction has been made for the absorption over long ranges (i.e. of the order of thousands of metres), based on measurements of high intensity noise propagation taken in the North and Irish Seas in similar depths to that present at Norfolk Vanguard.

374. The calculation also does not take into account the variation in the noise level at different depths. Where animals are swimming near the surface, the acoustics at the surface cause the noise level, and hence the exposure, to be lower at this position (MTD, 1996). The risk to animals near the surface may therefore be lower than

indicated by the range estimate and therefore this can be considered conservative in respect of impact at different depths.

375. The impact criteria use thresholds and weightings based on the NOAA (NMFS, 2016) criteria. The thresholds indicate the onset of PTS and TTS, or the point at which there is an increase in risk of permanent hearing damage in an underwater receptor. These are simple indicators and do not take into account the spreading of underwater sound over long distances, and thus there is a greater likelihood of accuracy where the ranges are small.

376. The thresholds group marine mammal species based on their hearing capabilities, for example, species that are particular sensitivity to high frequency sound, such as harbour porpoise, are classed as high-frequency cetaceans. The thresholds are weighted, which adjusts the sound present at the receiver based on the sensitivity of the receiver. Blast noise is fairly broadband, comprising a wide range of low to high frequency sound, although the majority is at low frequency.

377. Note that unweighted NMFS (2016) 230 dB SPL_{peak} is identical to the Southall *et al*. (2007) cetacean (all groups) threshold, and 218 dB SPL_{peak} thresholds are identical to the Southall *et al*. (2007) pinniped threshold.

12.7.4.1.3 Permanent auditory injury

378. The number of harbour porpoise, grey seal and harbour seal that could potentially be impacted was estimated for Norfolk Vanguard, based on the maximum potential PTS impact ranges of UXO clearance (Table 12.27). The resulting magnitude is shown to be **medium** for harbour porpoise, **negligible** for grey and harbour seal in the Norfolk Vanguard site and **low** for grey and harbour seal in the cable corridor, without mitigation.

379. Caution should also be raised over the longer range SPL_{peak} values. Peak noise levels are difficult to predict accurately in a shallow water environment (von Benda Beckmann, 2015) and would tend to be significantly over-estimated over ranges of the order of 3,000m compared to real data. Therefore, the use of NMFS weighted SEL is considered preferential at long range (see Appendix 5.4). However, as a precautionary approach and based on the current Natural England advice (20180209 NE position on NOAA UXOs and EPS) the assessment has been based on the worst-case scenarios for the unweighted SPL_{peak} predicted PTS impact ranges (Table 12.27) and weighted SEL predicted TTS impact ranges (Table 12.28).

380. A MMMP for UXO clearance will be produced post-consent in consultation with SNCBs and would be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Vanguard offshore project area, and detailed

project design. The MMMP for UXO clearance will detail the proposed mitigation measures to reduce the risk of any lethal injury, physical injury or permanent auditory injury to harbour porpoise during any underwater detonations. See Section 12.7.4.1.6.

Table 12.27 Potential impact of permanent auditory injury (PTS) on marine mammals during UXO clearance without mitigation

Species	Potential Impact	TNT Equivalent / Charge weights SOURCE LEVEL, SPL_{PEAK}	55kg 287.4 dB	120kg 290.0 dB	150kg 290.7 dB	250kg 292.4 dB	261kg 292.5 dB	525kg 294.8 dB	770kg 296.1 dB	Magnitude[2]
Harbour porpoise (high-frequency cetacean)	PTS SPL_{peak} Unweighted (NMFS, 2016)	202 dB re 1 µPa	5.4km	6.8km	7.3km	8.4km	8.5km	10.4km	11.5km	**Medium** Permanent (between 0.01% and 1% of the reference population)
	PTS SEL Weighted (NMFS, 2016)	155 dB re 1 $µPa^2s$	1.2km	1.7km	1.9km	2.4km	2.4km	3.3km	3.9km	
	Number of harbour porpoise and % of reference population[1] based on maximum impact range (11.5km) for PTS unweighted SPL_{peak} (NMFS, 2016)		Maximum impact area* based = 415.5km^2 368.5 harbour porpoise (0.1% of NS MU) based on SCANS-III survey density (0.888/km^2). 523.5 harbour porpoise (0.15% of NS MU) based on site specific survey density (1.26/km^2) at NV East[+]							
Grey seal and harbour seal (pinnipeds in water)	PTS SPL_{peak} Unweighted (NMFS, 2016)	218 dB re 1 µPa	1.2km	1.5km	1.6km	1.9km	1.9km	2.4km	2.7km	**Low** for grey and harbour seal in cable route Permanent (between 0.001% and 0.01% of the ref pop) **Negligible** for grey and harbour seal in OWF area (less than
	PTS SEL Weighted (NMFS, 2016)	185 dB re 1 $µPa^2s$	0.56km	0.82km	0.91km	1.2km	1.2km	1.7km	2.0km	
Grey Seal	Number of grey seal and % of reference population[1] based on maximum impact range (2.7km) for PTS unweighted SPL_{peak} (NMFS, 2016)		Maximum impact area* based on unweighted SPL_{peak} = 22.9km^2 0.05 grey seal (0.0002% ref pop; 0.0008% SE England MU) based on offshore wind farm area density (0.002/km^2). 4 grey seal (0.009% ref pop; 0.08% SE England MU) based on offshore cable corridor area density (0.16/km^2).							
Harbour seal	Number of harbour seal and % of reference population1 based on		Maximum impact area* based on unweighted SPL_{peak} = 22.9km^2 0.002 harbour seal (0.000005% ref pop; 0.00004% SE England MU) based on offshore wind							

Species	Potential Impact	TNT Equivalent / Charge weights SOURCE LEVEL, SPL_{PEAK}	55kg 287.4 dB	120kg 290.0 dB	150kg 290.7 dB	250kg 292.4 dB	261kg 292.5 dB	525kg 294.8 dB	770kg 296.1 dB	Magnitude[2]
	maximum impact range (2.7km) for PTS unweighted SPL_{peak} (NMFS, 2016)		farm area density (0.0001/km^2). 2.3 harbour seal (0.005% ref pop; 0.045% SE England MU) based on offshore cable corridor area density (0.1/km^2).							0.001% of ref pop)

*Maximum area based on area of circle with maximum impact range for radius; [+]Worst-case scenario based on greatest density estimate for the NV West and NV East sites.
[1]Based on density estimates and reference populations (see Table 12.20 and Table 12.21); [2] See Table 12.7 for definitions.

12.7.4.1.4 Temporary auditory injury and fleeing response

381. The number of harbour porpoise, grey seal and harbour seal that could potentially by impacted at Norfolk Vanguard, is estimated based on the maximum potential TTS impact ranges for UXO clearance (Table 12.28). The resulting effect is shown to be of **negligible** magnitude for harbour porpoise, grey seal and harbour seal, without mitigation.

382. The number of harbour porpoise, grey seal and harbour seal that could potentially be at risk of TTS has been estimated without mitigation. The implementation of the agreed mitigation measures within the UXO MMMP will reduce the risk of PTS by ensuring that marine mammals had moved out of the mitigation zone based on the maximum predicted range for PTS, therefore the number of animals that could be exposed to noise levels that could result in TTS would also be reduced.

Table 12.28 Potential maximum impact of temporary auditory injury (TTS) and fleeing response on marine mammals during UXO clearance

Species	Potential Impact	TNT Equivalent / Charge weights Source Level, SPL_{peak}	55kg 287.4 dB	120kg 290.0 dB	150kg 290.7 dB	250kg 292.4 dB	261kg 292.5 dB	525kg 294.8 dB	770kg 296.1 dB	Magnitude[2]
Harbour porpoise (high-frequency cetacean)	TTS SPL_{peak} Unweighted (NMFS, 2016)	196 dB re 1 µPa	9.2km	11.4km	12.1km	13.9km	14.0km	16.8km	18.4km	**Negligible** Temporary (less than 1% of the reference population)
	TTS SEL Weighted (NMFS, 2016)	140 dB re 1 μPa^2s	11.5km	14.9km	16.0km	18.7km	18.9km	23.0km	25.5km	
	Number of harbour porpoise and % of reference population[1] based on maximum impact range (25.5km) for TTS SEL Weighted (NMFS, 2016)		Maximum impact area* based on weighted TTS SEL = 2,043km^2 1,814 harbour porpoise (0.5% of NS MU) based on SCANS-III survey density (0.888/km^2). 2,574 harbour porpoise (0.7% of NS MU) based on site specific survey density (1.26/km^2) at NV East[+]							
Grey seal and harbour seal (pinnipeds in water)	TTS SPL_{peak} Unweighted (NMFS, 2016)	212 dB re 1 µPa	2.1km	2.7km	2.9km	3.4km	3.4km	4.3km	4.8km	**Negligible** Temporary (less than 1% of the reference population)
	TTS SEL Weighted (NMFS, 2016)	170 dB re 1 μPa^2s	6.5km	8.8km	9.5km	11.4km	11.6km	14.7km	16.6km	
Grey Seal	Number of grey seal and % of reference population[1] based on maximum impact range (16.6km) for TTS SEL Weighted (NMFS, 2016)		Maximum impact area* based weighted TTS SEL = 866km^2 1.7 grey seal (0.008% ref pop; 0.03% SE England MU) based on offshore wind farm area density (0.002/km^2). 138.6 grey seal (0.6% ref pop; 2.3% SE England MU) based on offshore cable corridor area density (0.16/km^2).							
Harbour seal	Number of harbour seal and % of reference population1 based on		Maximum impact area* based on weighted TTS SEL = 866km^2 0.09 harbour seal (0.0002% ref pop; 0.002% SE England MU) based on offshore wind farm							

Species	Potential Impact	TNT Equivalent / Charge weights	55kg	120kg	150kg	250kg	261kg	525kg	770kg	Magnitude[2]
		Source Level, SPL_{PEAK}	287.4 dB	290.0 dB	290.7 dB	292.4 dB	292.5 dB	294.8 dB	296.1 dB	
	maximum impact range (16.6km) for TTS SEL Weighted (NMFS, 2016)		area density (0.0001/km^2). 86.6 harbour seal (0.2% ref pop; 1.7% SE England MU) based on offshore cable corridor area density (0.1/km^2).							

*Maximum area based on area of circle with maximum impact range for radius; [+]Worst-case scenario based on greatest density estimate for the NV West and NV East sites.
[1]Based on density estimates and reference populations (see Table 12.20 and Table 12.21); [2] See Table 12.7 for definitions

12.7.4.1.5 Disturbance

383. For harbour porpoise, grey seal and harbour seal, a fleeing response is assumed to occur at the same noise levels as TTS. As outlined in Southall *et al*. (2007) the onset of behavioural disturbance is proposed to occur at the lowest level of noise exposure that has a measurable transient effect on hearing (i.e. TTS-onset). Although, as Southall *et al*. (2007) recognise that this is not a behavioural effect *per se* exposures to lower noise levels from a single pulse are not expected to cause disturbance, however any compromise, even temporarily, to hearing functions could have the potential to affect behaviour.

384. Although mitigation in the MMMP for UXO clearance will increase the distance of marine mammals from any UXO detonations (section 12.7.1.2.2), it cannot mitigate the potential disturbance to marine mammals.

385. The SNCBs currently recommend that a potential disturbance range of 26km (approximate area of 2,124km^2) around UXO detonations is used to assess the area that harbour porpoise may be disturbed in the Southern North Sea (SNS) cSAC. Norfolk Vanguard is located within the SNS cSAC therefore this approach has been used for the EIA.

386. The estimated number of harbour porpoise, grey seal and harbour seal that could potentially be disturbed during underwater UXO clearance, based on a 26km radius, is presented in Table 12.29. The resulting impact is shown to be of **negligible** magnitude for harbour porpoise and harbour seal and **low** for grey seal, without mitigation.

387. Disturbance from a UXO detonations would be temporary and for a short-duration (i.e. the detonation). For the estimated worst-case (Table 12.24) it is predicted that there could be up to nine clearance operations in NV East, five in NV West and 28 in the offshore cable corridor based on initial geophysical data (Fugro, 2016), but numbers will be determined by a pre-construction UXO survey. As a precautionary worst-case scenario, the maximum number of days of UXO clearance could be up to 42 days, based on one detonation per day.

Table 12.29 Estimated number of harbour porpoise, grey seal and harbour seal that could potentially be disturbed during UXO clearance

Potential Impact	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
Area of disturbance (2,124km^2) during underwater UXO clearance	Harbour porpoise	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,676 harbour porpoise	0.55% of NS MU based on SCANS-III density. 0.8% of NS MU based on the most conservative site specific survey	Temporary effect with **negligible** magnitude (i.e. less than 1% of the reference

Potential Impact	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
		based on site specific survey density ($1.26/km^2$) at NV East. 1,678 harbour porpoise based on site specific survey density ($0.79/km^2$) at NV West.	density (NV East).	population anticipated to be exposed to effect).
	Grey seal	4 grey seal based on offshore wind farm area density ($0.002/km^2$). 340 grey seal based on offshore cable corridor area density (0.16/km2).	0.02% ref pop (0.07% SE England MU) for OWF area. 1.5% ref pop (5.6% SE England MU) for cable corridor.	Temporary effect with **negligible** magnitude for OWF area. Temporary effect with **low** magnitude for cable corridor (between 1% of 5% of the reference population).
	Harbour seal	0.2 harbour seal based on offshore wind farm area density ($0.0001/km^2$). 212 harbour seal based on offshore cable corridor area density ($0.1/km^2$).	0.0005% ref pop (0.004% SE England MU) for OWF area. 0.5% ref pop (4.2% SE England MU) for cable corridor.	Temporary effect with **negligible** magnitude for OWF area and cable corridor.

[1]Based on density estimates and reference populations (see Table 12.20 and Table 12.21);
[2] See Table 12.7 for definitions.

388. The spatial assessment of the potential effects of disturbance during UXO clearance on the SNS cSAC, taking into account the potential maximum and average area of possible displacement of harbour porpoise based on the worst-case scenario for UXO clearance at NV East, NV West and the offshore cable corridor forms part of the assessment for the Report to inform the HRA (document reference 5.3)

12.7.4.1.6 Impact significance

389. Taking into account the receptor sensitivity and the potential magnitude of the impact (e.g. number of individuals as a percentage of the reference population) and if the impact is permanent (e.g. PTS) or temporary (e.g. TTS and disturbance), the impact significance for any physical injury, permanent auditory injury, temporary auditory injury / fleeing response and disturbance in harbour porpoise, grey seal and harbour seal has been assessed as **major adverse** without mitigation for PTS in

harbour porpoise and **moderate** to **minor adverse** without mitigation for PTS in grey and harbour seal (Table 12.30).

390. It should be noted that the conclusion of major adverse without mitigation for PTS in harbour porpoise is very precautionary, as the assessment is based on the worst-case scenario for the largest UXO device that may (or may not) be present with the Norfolk Vanguard site.

391. The risk of TTS in harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant) for UXO clearance, with no mitigation (Table 12.30).

392. The potential disturbance of harbour porpoise, grey seal and harbour seal during UXO clearance has been assessed as **minor adverse** (not significant) for UXO clearance, with no mitigation (Table 12.30).

Mitigation

393. A MMMP for UXO clearance will be produced post-consent in consultation with the MMO and relevant SNCBs and will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Vanguard offshore project area and detailed project design. The MMMP for UXO clearance will detail the proposed mitigation measures to reduce the risk of any lethal injury and permanent auditory injury to marine mammals during any underwater detonations.

394. The MMMP for UXO clearance will be developed post-consent and will be agreed with the relevant SNCBs prior to any UXO works progressing.

395. The MMMP for UXO clearance will involve the establishment of a suitable mitigation zone around the UXO location before any detonation. Norfolk Vanguard Limited will ensure that the mitigation measures are adequate to ensure no marine mammals are present within the mitigation zone prior to any UXO detonation, to reduce the risk of any physical or permanent auditory injury (PTS).

396. The methods for achieving the mitigation zone will be agreed in consultation with the relevant SNCBs and secured as commitments within the final MMMP for UXO clearance, based on the most suitable techniques and current guidance.

397. The MMMP for UXO clearance will include details of all the required mitigation measures to minimise the potential risk of physical and auditory injury (PTS) as a result of underwater noise during UXO clearance, for example, this would consider the options, suitability and effectiveness of mitigation measures such as, but not limited to:

- The activation of acoustic deterrent devices (ADDs).

- If required and where possible and safe to do so, a soft-start procedure using scare charges.
- Noise reduction mitigation measures, such as bubble curtains.
- Monitoring of the mitigation zone by marine mammal observers (MMOs) during daylight hours and when conditions allow suitable visibility, pre- and post-detonation.
- Deployment of passive acoustic monitoring (PAM) devices, if required, for example during poor visibility and if the equipment can be safely deployed and retrieved prior to detonation.
- All detonations taking place in daylight and, when possible, in favourable conditions with good visibility.
- The controlled explosions of the UXO, undertaken by specialist contractors, using the minimum amount of explosives required in order to achieve safe disposal of the device.
- The sequencing of detonations, if there are multiple UXO in close proximity to be disposed of near simultaneously, where practicable, will start with the smallest detonation and end with the larger detonations.

398. The final MMMP for UXO clearance will detail what is required for all agreed mitigation measures to ensure that they are successfully undertaken, including if marine mammals are observed in the mitigation zone.

399. An EPS licence application, if required, will be submitted post-consent. At this time, pre-construction UXO surveys will have been conducted, as well as full consideration of the mitigation measures that will be in place following the development of the MMMP for UXO clearance.

Residual impact

400. The residual impact of the potential risk of physical injury and permanent auditory injury to marine mammals as a result of any underwater UXO clearance is reduced to a negligible magnitude taking into account the proposed mitigation to reduce the potential effects, therefore with high sensitivity the potential impact significance for any physical injury or permanent auditory injury, it is likely to reduce the overall impact significance to **minor adverse** (not significant) (Table 12.30).

Table 12.30 Assessment of impact significance for UXO clearance on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Permanent auditory injury (PTS) during underwater UXO clearance	Harbour porpoise	High	Medium based on worst-case scenario (Table	Major	MMMP for UXO clearance.	**Minor adverse** (high sensitivity and

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
			12.27)			negligible magnitude)
	Grey and harbour seal	High	Low to Negligible based on worst-case scenario (Table 12.27)	Moderate to Minor		**Minor adverse** (high sensitivity and negligible magnitude)
Temporary auditory injury (TTS) and fleeing response during underwater UXO clearance	Harbour porpoise	Medium	Negligible	Minor	MMMP for UXO clearance.	**Minor adverse**
	Grey and harbour seal	Medium	Negligible	Minor		**Minor adverse**
Disturbance during UXO clearance	Harbour porpoise	Medium	Negligible	Minor	MMMP for UXO clearance and SIP for SNS cSAC.	**Minor adverse**
	Grey seal	Medium	Low	Minor		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor		**Minor adverse**

12.7.4.2 Impact 2: Underwater noise during piling

401. A range of foundation options are being considered for Norfolk Vanguard, including monopile, jacket (tripod or quadropod), gravity base, suction caisson and tension leg floating platforms. Of these, monopiles, jackets and floating foundations may require piling.

402. Impact piling has been proposed to drive the foundation piles of the wind turbines into the seabed. Impact piling has been established as a source of high level underwater noise (Würsig *et al*., 2000; Caltrans, 2001; Nedwell *et al*., 2003 and 2007; Parvin *et al*., 2006; Thomsen *et al*., 2006).

403. During impact piling, noise is created in air by the hammer as a direct result of the impact of the hammer with the pile; some of this airborne noise is transmitted into the water. Of more significance to the underwater noise is the direct radiation of noise from the pile into the water because of the compressional, flexural or other complex structural waves that travel down the pile following the impact of the hammer on its head. Structural pressure waves in the submerged section of the pile transmit sound efficiently into the surrounding water. These waterborne pressure waves will radiate outwards, usually providing the greatest contribution to the underwater noise.

404. Underwater noise can cause both physiological (e.g. lethal, physical injury and auditory injury) and behavioural (e.g. disturbance and masking of communication) impacts on marine mammals (e.g. Bailey *et al*., 2010; Madsen *et al*., 2006; Thomsen *et al*., 2006, Thompson *et al*., 2010b).

405. Should a marine mammal be very close to the source, the high peak pressure sound levels have the potential to cause death or physical injury, with any severe injury potentially leading to death, if no adequate mitigation is in place.

406. High exposure levels from underwater sound sources can cause auditory injury or hearing impairment taking the form of a permanent loss of hearing sensitivity (PTS) or a temporary loss in hearing sensitivity (TTS). The potential for auditory injury is not just related to the level of the underwater sound and its frequency relative to the hearing bandwidth of the animal, but is also influenced by the duration of exposure. The level of impact on an individual is a function of the SEL that an individual receives as a result of underwater noise.

407. Marine mammals may exhibit varying intensities of behavioural response at lower noise levels. These include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour, temporary or permanent habitat abandonment, and in severe cases panic, flight stampede or stranding, sometimes resulting in injury or death. The response can vary due to exposure level, the hearing sensitivity of the individual, context, previous exposure history or habituation, motivation and ambient noise levels (e.g. Southall *et al*., 2007).

408. The potential impacts of underwater noise are dependent on the noise source characteristics, the receptor species, distance from the sound source and noise attenuation within the environment.

409. The potential impact of underwater noise will depend on a number of factors which include, but are not limited to:

- The source levels of noise;
- Frequency relative to the hearing bandwidth of the animal;
- Duration of exposure;
- Distance of the animal to the source; and
- Ambient noise levels.

410. The spatial footprint of the impact as a feature of noise propagation conditions will depend on several factors, including, but not limited to:

- Sediment/sea floor composition;

- Water depth; and
- The sensitivity of marine mammal species present in the area.

12.7.4.2.1 Underwater noise modelling

411. Subacoustech has undertaken predictive underwater noise modelling to estimate the noise levels likely to arise during construction of Norfolk Vanguard and determine the potential impacts on marine mammals (Appendix 5.3).

412. Underwater noise modelling was carried out by Subacoustech (Appendix 5.3) using a combined parabolic equation (PE) and ray tracing method considering bathymetry, seabed type and frequency content at all depths in the water column. The methods used meet the requirements set by the National Physical Laboratory (NPL) Good Practice Guide 133 for underwater noise measurement (Robinson *et al*., 2014).

413. The underwater noise modelling used in this assessment used a numerical approach based on:

- A PE method for lower frequencies (12.5 Hz to 250 Hz); and
- A ray tracing method for higher frequencies (315 Hz to 100 kHz).

414. The modelling considers a wide array of input parameters, including variations in bathymetry, sediment data, sound speed and source frequency content to ensure as detailed results as possible. It should also be noted that the results presented in this assessment are precautionary as the worst-case parameters have been selected for:

- Piling hammer energies;
- Ramp-up profile and strike rate;
- Duration of piling;
- Receptor swim speeds; and
- Position of the receptor in the water column.

415. The modelling takes account of the environmental parameters within the study area and the characteristics of the noise source.

Piling locations

416. Underwater noise modelling was undertaken at four representative locations, two in NV West, covering the position closest to land (SW) and the furthest position from this location (NE) in NV West, and two in NV East (following the pattern from NV West; Appendix 5.3).

417. The two locations at NV West are representative of the worst-case for the NV West and NV East sites as the deeper water in NV West is conducive of higher noise source levels and greater overall noise propagation.

418. The NV West locations represent the worst-case scenario for underwater noise propagation and these were used to assess the potential impacts on receptor groups (Table 12.31). In order to provide a conservative assessment, the worst-case scenario, e.g. greatest potential impact range is applied to any location within NV West or NV East.

Table 12.31 Underwater noise modelling locations

	Norfolk Vanguard West	
Location	**South West (SW)**	**North East (NE)**
Latitude	52.80098°N	53.04354°N
Longitude	002.44379°E	002.57117°E

Hammer energy, soft-start and ramp-up

419. The underwater noise modelling is based on the following worst-case scenarios for monopiles and pin-piles:

- Monopile with maximum diameter of 15m, maximum hammer energy of 5,000kJ and maximum starting energy of 500kJ.
- Pin-pile with minimum diameter of 3m, maximum hammer energy of 2,700kJ and maximum starting hammer energy of 270kJ.

420. For the SEL_{cum}, the soft-start and ramp up takes place over the first 30 minutes of piling, with the soft-start for a minimum of 10 minutes at 10% of maximum hammer energy, then a minimum of 20 minutes for the ramp-up, during which there will be a gradual increase in hammer energy and strike rate until reaching the maximum hammer energy where it is assumed to remain for the duration of the pile installation (however, maximum hammer energy is only likely to be required at a few of the piling installation locations). The soft-start, ramp-up and piling duration used to assess SEL_{cum} for monopiles and pin-piles are summarised in Table 12.32.

421. The monopile scenario contains 7,200 pile strikes over 255 minutes (4 hours 15 minutes). The pin-pile scenario includes four individual piles installed consecutively, leading to a total of 8,400 strikes over 6 hours (1 hour 30 minutes for each pin pile). For the purposes of noise modelling, it is assumed that there is no pause between each individual pin-pile, as it is assumed that the marine mammal will continue swimming away from the source.

Table 12.32 Hammer energies, ramp-up and duration used for calculating cumulative SELs

	Starting hammer energy (10%)	Ramp-up	Maximum hammer energy (100%)
Monopile			
Monopile hammer energy	500kJ	Gradual increase	5,000kJ
Number of strikes	150 strikes	300 strikes	6,750 strikes

	Starting hammer energy (10%)	Ramp-up	Maximum hammer energy (100%)
Duration	10 minutes	20 minutes	225 minutes
Pin-pile			
Pin-pile hammer energy	270kJ	Gradual increase	2,700kJ
Number of strikes	150 strikes	300 strikes	1,650 strikes
Duration	10 minutes	20 minutes	60 minutes

422. The size of the pile being installed is used for estimating the frequency content of the noise. For this modelling, frequency data has been sourced from Subacoustech's noise measurement database and an average taken to obtain representative third-octave levels, i.e. frequency levels for installing monopiles and pin piles (for further details see Appendix 5.3).

423. Piles more than 7m in diameter, the largest where measured data is available, have been used for the monopile modelling and piles of approximately 4m in diameter (mid-way between the 3m and 5m pin-pile options currently under consideration) have been used for pin-pile modelling (for further details see ES Appendix 5.1).

424. Monopiles contain more low frequency content and the pin-piles contain more high frequency content, due to the acoustics related to the dimensions of the pile. This trend would be expected to continue to larger piles under consideration for the monopiles at Norfolk Vanguard. A larger diameter would be expected to move the dominant frequency of the sound produced lower, further below the frequencies of greatest hearing sensitivity of marine mammals, and thus the sound would appear slightly quieter to a receptor.

425. The radiating pile length in the water would not change, provided that the hammer remains above the surface of the water. Investigations with limited data for subsea piling have shown that the difference to the situation where the hammer is above the water is small. It is thought that, while the radiating area would progressively reduce for subsea hammer piling, the introduction of the hammer itself would contribute to the noise, perhaps offsetting the effect.

Environmental conditions

426. Accurate modelling of underwater noise propagation requires knowledge of the sea and seabed conditions. Data from the Marine Environment Mapping Programme (MAREMAP) and the British Geological Survey (BGS) was used to determine the seabed type used for the modelling, which was made up predominantly of sand. This is supported by the Norfolk Vanguard site specific benthic survey (see Appendix 10.1). The geoacoustic properties for the sediment types are taken from Jensen *et al*. (2011).

427. The speed of sound in water at Norfolk Vanguard has been calculated using mean temperature and salinity data for the North Sea over the whole year. The levels used in the model vary from 1,489.1m/s at the surface to 1,490.7m/s in the deepest waters.

428. Mean tidal depth was used throughout for the bathymetry, as the tidal state will fluctuate throughout installation of foundations. The tidal range at the site varies between 3.2m above chart datum at Mean High Water Spring (MHWS) and 0.6m above chart datum at Mean Low Water Spring MLWS, using the mean depth is a reasonable assumption to cover the differences in the tide variation.

Baseline ambient noise

429. The baseline noise level in open water, in the absence of any specific anthropogenic noise source, is generally dependent on a mix of the movement of the water and sediment, weather conditions and shipping. There is a component of biological noise from marine mammal and fish vocalisation, as well as invertebrates.

430. Outside of the naturally occurring ambient noise, man-made noise dominates the background. The North Sea is heavily shipped by fishing, cargo and passenger vessels, which contribute to the ambient noise in the water. Other sources of anthropogenic noise include oil and gas platforms and drilling activity. Drilling may contribute some low frequency noise in the Norfolk Vanguard study area, although this is unlikely to contribute to the overall ambient noise (Appendix 5.3).

431. In 2011, snapshot baseline underwater noise levels were sampled in the same region as Norfolk Vanguard as part of the met-mast installation noise survey in the Hornsea Zone (Nedwell and Cheesman, 2011). Measurements were taken outside of the installation activity and in the absence of any nearby vessel noise. This survey sampled noise levels of 112 to 122 dB re 1 µPa RMS over two days, and were described as 'not unusual' for the area. The higher noise level was due to higher sea state on that day. However, unweighted overall noise levels of this type should be used with caution without access to more detail regarding the duration, frequency content and conditions under which the sound was recorded (Appendix 5.3).

Noise source levels

432. Underwater noise modelling requires knowledge of the source level, which is the theoretical noise level at 1m from the noise source. Subacoustech has undertaken numerous measurements of impact piling offshore and have developed a sound level model based primarily on the hammer energy and water depth of a piling operation, which have been shown to be the primary factors when comparing piling operations and the subsequent subsea noise levels produced, see Appendix 5.3.

433. As the model assumes that the noise source acts as a single point, the water depth at the noise source has been used to adjust the source level to allow for the length of pile in contact with the water.

434. The unweighted SPL_{peak} source levels estimated for this assessment are provided in Table 12.33.

Table 12.33 Unweighted source levels (SPL_{peak}) used in underwater noise modelling for maximum and starting hammer energy

Location	Monopile source level (5,000kJ)	Pin-pile source level (2,700kJ)	Monopile source level (500kJ)	Pin-pile source level (270kJ)
South-West (SW) location at NV West	243.6 dB re 1 µPa @ 1 m	241.3 dB re 1 µPa @ 1 m	232.4 dB re 1 µPa @ 1 m	228.1 dB re 1 µPa @ 1 m
North-East (NE) location at NV West	241.5 dB re 1 µPa @ 1 m	239.1 dB re 1 µPa @ 1 m	229.9 dB re 1 µPa @ 1 m	225.6 dB re 1 µPa @ 1 m

Thresholds and criteria

435. Sound measurements underwater are usually expressed using the decibel (dB) scale, which is a logarithmic measure of sound.

436. The sound pressure level (SPL) is normally used to characterise noise and vibration of a continuous nature. The variation in sound pressure can be measured over a specific time period to determine the root mean square (RMS) level of the time varying acoustic pressure, therefore SPL (i.e. SPL_{RMS}) can be considered as a measure of the average unweighted level of the sound over the measurement period.

437. Peak SPLs (SPL_{peak}) are often used to characterise sound transients from impulsive sources, such as percussive impact piling. A peak SPL is calculated using the maximum variation of the pressure from positive to zero within the wave. This represents the maximum change in positive pressure (differential pressure from positive to zero) as the transient pressure wave propagates.

438. The sound exposure level (SEL) sums the acoustic energy over a measurement period, and effectively takes account of both the SPL of the sound source and the duration the sound is present in the acoustic environment (further details are provided in Appendix 5.3).

439. SEL_{ss} is the potential sound exposure level from a single strike of the hammer, e.g. one hammer strike at the starting hammer energy or maximum hammer energy.

440. SEL_{cum} is the cumulative sound exposure level during the duration of piling including the soft-start, ramp-up and time required to complete the installation of the pile (Table 12.32). To determine SEL_{cum} ranges, a fleeing animal model has been used. This assumes that the animal exposed to high noise levels will swim away from the noise source. For this a constant fleeing speed of 1.5 m/s has been used, which is

based on the average swimming speed for a harbour porpoise (Otani *et al*., 2000). This is considered a 'worst-case' scenario as marine mammals are expected to be able to swim faster. For example, the swimming speed of a harbour porpoise during playbacks of pile driving sounds (SPL of 154 dB re 1 µPa) was 1.97 m/s (7.1km/h) and during quiet baseline periods the mean swimming speed was 1.2 m/s (4.3km/h; Kastelein *et al*., 2018).

441. The metrics and criteria that have been used to assess the potential impact of underwater noise on marine mammals are based on, at the time of writing, the most up to date publications and recommended guidance.

442. The assessment in the ES considers the metrics and criteria from NOAA (NMFS, 2016) and Lucke *et al*. (2009) to assess the potential effects of impact piling noise on marine mammals. This was agreed with the marine mammal ETG as part of the EPP.

443. In addition, Appendix 12.5 also presents the potential effects of impact piling noise on marine mammals using the criteria proposed by Southall *et al*. (2007). This was agreed with the marine mammal ETG as part of the EPP.

444. NOAA (NMFS, 2016) produced technical guidance for assessing the effects of underwater anthropogenic sound on the hearing of marine mammal species. This guidance identifies the received levels, or acoustic thresholds, at which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for acute, incidental exposure to underwater anthropogenic sound sources.

445. The NOAA guidance (NMFS, 2016) comprehensively reviewed the latest research on the effects of anthropogenic underwater noise and changed most criteria used to estimate the impacts: primarily the noise level threshold at which onset of the hearing damage could occur in a species group with reference to the species group's hearing sensitivity.

446. NMFS (2016) present single strike, unweighted peak criteria (SPL_{peak}) and cumulative (i.e. more than a single sound impulse), weighted sound exposure criteria (SEL_{cum}) for both PTS where unrecoverable hearing damage may occur and TTS where a temporary reduction in hearing sensitivity may occur in individual receptors.

447. The NOAA (NMFS, 2016) metrics and criteria used in the underwater noise modelling are summarised in Table 12.34.

448. NOAA (NMFS, 2016) groups marine mammals into functional hearing groups and applies filters to the unweighted noise to approximate the hearing sensitivity of the receptor.

Table 12.34 NOAA (NMFS, 2016) metrics and criteria used in the underwater noise modelling

Species or species group	Impact	NOAA (NMFS, 2016) SPL$_{peak}$ Unweighted (dB re 1 µPa)	NOAA (NMFS, 2016) SEL$_{cum}$ Weighted (dB re 1 µPa^{2}s)
Harbour porpoise High Frequency Cetaceans (HF)	Auditory Injury -PTS (Permanent Threshold Shift)	202	155
	TTS and fleeing response (Temporary Threshold Shift)	196	140
Grey seal and harbour seal Pinnipeds in water	Auditory Injury - PTS (Permanent Threshold Shift)	218	185
	TTS and fleeing response (Temporary Threshold Shift)	212	170

449. The criteria from Lucke *et al*. (2009) are derived from testing harbour porpoise hearing thresholds before and after being exposed to seismic airgun stimuli (a pulsed noise like impact piling). The Lucke *et al*. (2009) criteria for possible behavioural response in harbour porpoise used in the assessment are unweighted single strike SELs (Table 12.35).

Table 12.35 Lucke *et al*. (2009) metrics and criteria used in the underwater noise modelling

Species or species group	Impact	Lucke *et al*. (2007) SEL$_{ss}$ Unweighted (dB re 1 µPa^{2}s)
Harbour porpoise	Possible Behavioural Response	145

Assumptions and considerations

450. It should be noted and taken into account that the underwater noise modelling and assessment is based on 'worst-case' scenarios and precautionary approaches, this includes, but not limited to:

- Maximum hammer energies and maximum piling duration is assumed for all piling locations; however, it is unlikely that maximum hammer energy and duration will be required at the majority of piling locations.
- The maximum predicted impact ranges are based on the location with the greatest potential noise propagation range and this was assumed as the worst-case for each piling location.
- Impact ranges for a single strike are from the piling location and do not take into account (i) mitigation measures, such as soft-start or the use of ADDs to move marine mammals out of the area where there could be a risk of physical or auditory injury; or (ii) the potential disturbance and movement of marine

mammals away from the site as a result of the vessels and set-up prior to mitigation.

- The assumption that fleeing animals (harbour porpoise, grey seal and harbour seal) are swimming at a constant speed of 1.5 m/s (based on harbour porpoise mother calf pairs; Otani *et al*., 2000), however, marine mammals are expected to swim much faster. For example, harbour porpoise have been recorded swimming at speeds of up to 4.3m/s (Otani *et al*., 2000) and, as outlined above, Kastelein *et al*. (2018) reported swimming speed of a harbour porpoise during playbacks of pile driving sounds of 1.97m/s.
- The assumption that animals are submerged 100% of the time which does not account for any time that a receptor may spend at the surface or the reduced SELs near the surface where the animal would not be exposed to such high levels or for seals having their head out of the water.

451. Underwater noise modelling assumes that marine mammals will travel in the mid-water column where sound pressure levels are greatest. However, in reality animals would not be subjected to these high sound pressure levels at all times since they are likely to move up and down through the water column, and surface to breathe, where the sound pressure would drop to zero. A study by Teilmann *et al*. (2007) on diving behaviour of harbour porpoise in Danish waters suggests that animals spent 55% of their time in the upper 2m of the water column from April to August and over the whole year they spent 68% of their time in less than 5m depth. However, it should be noted that this study was conducted for “undisturbed” animals, which could show a different behaviour.

452. The swimming patterns of harbour porpoise undertaking direct travel are typically characterised by short submergence periods, compared to feeding animals (Watson and Gaskin, 1983). These short duration dives with horizontal travel suggest that travelling animals, such as harbour porpoise moving away from pile driving noise, would swim in the upper part of the water column. It would be anticipated, that during a fleeing response, from a loud underwater noise, such as piling, that their swimming behaviour may change with a reduction in deep dives. For example, during pile driving playback sounds to examine TTS, harbour porpoise showed behaviour response during the exposure periods, which included increased swimming speeds and jumping out of the water more (Kastelein *et al*. 2016). This behavioural response would allow the animal to move to a greater distance from the adverse noise source in a shorter period of time and result in exposure to lower noise propagation close to the sea surface, compared to mid-water at a comparable distance (Nabe-Nielsen Pers. Comm).

453. Noise impact assessments assume that all animals within the noise contour may be affected to the same degree for the maximum worst-case scenario. For example, that all animals exposed to noise levels that induce behavioural avoidance will be displaced or all animals exposed to noise levels that are predicted as inducing PTS or TTS will suffer permanent or temporary auditory injury respectively. However, a study looking at the proportion of trials at different SELs that result in TTS in exposed bottlenose dolphins suggests that to induce TTS in 50% of animals it would be necessary to extrapolate well beyond the range of measured SEL levels (Finneran *et al*., 2005). This 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. Further work by Thompson *et al*. (2013b) has adopted this dose-response curve to produce a theoretical dose-response for PTS in harbour seal by scaling up Finneran *et al*. (2005) dose response curve for changes in levels of TTS at different SEL, where the probability of seals experiencing PTS increases from an SEL of 186 up to 240 dB re 1 μPa^2 s; the point at which all animals are predicted to have PTS.

12.7.4.2.2 Permanent auditory injury

Permanent auditory injury sensitivity

454. All species of cetaceans rely on sonar for navigation, finding prey and communication; they are therefore highly sensitive to permanent hearing damage (Southall *et al*. 2007). However, when considering the impact that any auditory injury has on an individual, the frequency range over which the auditory injury occurs must be considered. PTS would normally only be expected in the critical hearing bands in and around the critical band of the fatiguing sound (e.g. Kastelein *et al*., 2012). Auditory injury resulting from sound sources like piling (where most of the energy occurs at lower frequencies) is unlikely to negatively affect the ability of high-frequency cetaceans to communicate or echo-locate. As such, sensitivity to PTS from pile driving noise is assessed as **high** for harbour porpoise (Table 12.36).

455. Pinnipeds use sound both in air and water for social and reproductive interactions (Southall *et al*., 2007), but not for finding prey. Therefore, Thompson *et al*. (2012) suggest damage to hearing in pinnipeds may not be as important as it could be in cetaceans. Pinnipeds also have the ability to hold their heads out of the water during exposure to loud noise, and potentially avoid PTS during piling. As such, sensitivity to PTS in harbour and grey seal is probably lower than harbour porpoise, with the individual showing some tolerance to avoid, adapt to or accommodate or recover from the impact, but as a precautionary approach they are considered as having **high** sensitivity in this assessment (Table 12.36).

456. Marine mammals within the potential impact area are considered to have very limited capacity to avoid such effects, and unable to recover from the effects.

Table 12.36 Summary of marine mammal sensitivity to noise impacts from pile driving

Species	Lethal effect or physical injury	Auditory injury (PTS)	Onset of TTS / fleeing response	Disturbance (likely avoidance)	Possible behavioural response
Harbour porpoise	High	High	Medium	Medium	Low
Grey and harbour seal	High	High	Medium	Medium	N/A

Permanent auditory injury magnitude

457. The underwater noise modelling results for the maximum predicted ranges (and areas) for permanent auditory injury (PTS) in harbour porpoise, grey seal and harbour seal are presented in Table 12.37 for the following:

- Single strike SPL_{peak} for maximum starting hammer energy of 500kJ for monopile;
- Single strike SPL_{peak} for maximum starting hammer energy of 270kJ for pin-piles;
- Single strike SPL_{peak} for monopile with maximum hammer energy of 5,000kJ;
- Single strike SPL_{peak} for pin-pile with a maximum hammer energy of 2,700kJ; and
- Cumulative SEL taking into account soft-start and ramp-up plus duration to install pile at maximum hammer energy. For the pin-piles the SEL_{cum}, is based on the duration to install four pin-piles for each foundation (not per individual pin-pile).

458. Based on:

- NOAA (NMFS, 2016) criteria for unweighted SPL_{peak} and PTS from cumulative exposure (SEL_{cum}) for harbour porpoise and seals.

Table 12.37 Maximum predicted impact ranges (and areas) for permanent auditory injury (PTS) from a single strike and from cumulative exposure based on NOAA (NMFS, 2016) criteria

Potential Impact	Receptor	Criteria and threshold	Maximum predicted impact range (km) and area* (km^2)			
			Monopile starting hammer energy of 500kJ	Monopile with maximum hammer energy of 5,000kJ	Pin-pile starting hammer energy of 270kJ	Pin-pile with maximum hammer energy of 2,700kJ
PTS without mitigation – single strike	Harbour porpoise	NMFS (2016) unweighted SPL_{peak} 202 dB re 1 µPa	0.42km ($0.55km^2$)	2.8km ($19.2km^2$)	0.17km ($0.09km^2$)	1.9km ($9.5km^2$)

Potential Impact	Receptor	Criteria and threshold	Maximum predicted impact range (km) and area* (km^2)			
			Monopile starting hammer energy of 500kJ	Monopile with maximum hammer energy of 5,000kJ	Pin-pile starting hammer energy of 270kJ	Pin-pile with maximum hammer energy of 2,700kJ
PTS without mitigation – single strike	Grey seal and harbour seal	NMFS (2016) unweighted SPL_{peak} 218 dB re 1 µPa	0.017km ($0.001km^2$)	0.16km ($0.06km^2$)	0.007km ($0.0001km^2$)	0.098km ($0.02km^2$)
PTS from cumulative SEL (including soft-start and ramp-up)	Harbour porpoise	NMFS (2016) SEL_{cum} Weighted 155 dB re 1 $µPa^2s$	N/A	0.42km ($0.2km^2$)	N/A	1.5km ($3.4km^2$)
PTS from cumulative SEL (including soft-start and ramp-up)	Grey seal and harbour seal	NMFS (2016) SEL_{cum} Weighted 185 dB re 1 $µPa^2s$	N/A	2.4km ($13.6km^2$)	N/A	1.7km ($5.3km^2$)

*areas for maximum hammer energies for monopile and pin-pile based on modelled contour area; area for starting hammer energy based on worst-case scenario for area of circle with maximum impact range as radius.

Harbour porpoise PTS from first strike of soft-start

459. The estimated maximum area within which PTS could occur in harbour porpoise (Figure 12.5) is estimated to be $0.55km^2$ for the maximum starting hammer energy (500kJ) (Table 12.37).

460. The estimated maximum number of harbour porpoise that could potentially be at risk of PTS as a result of a single strike of the maximum starting hammer energy of 500kJ is 0.7 individuals (0.0002% of the North Sea MU reference population). This is based on the site specific density for NV East (1.26 harbour porpoise per km^2) and the maximum noise propagation (Table 12.38). The magnitude of the potential impact is assessed as **negligible** with less than 0.001% of the reference population anticipated to be exposed to effect without mitigation.

461. Mitigation in the MMMP for piling, such as the activation of ADDs prior to the first strike of the soft-start would allow harbour porpoise to move away prior to the soft-start and ramp-up, therefore reducing the number of harbour porpoise within the potential PTS impact range for the first strike of the soft-start. For example, the activation of ADDs for just 10 minutes prior to the soft-start would allow harbour porpoise and other marine mammals to move at least 0.9km from the piling location

(based on a precautionary average swimming speed of 1.5m/s), which is beyond the maximum PTS predicted impact range of 0.42km for the starting hammer energy of up to 500kJ. Therefore, after the ADD activation there should be no harbour porpoise in the potential impact range for PTS from the first strike of the soft-start and therefore with mitigation the potential magnitude would be **negligible**.

Pinniped PTS from first strike of soft-start

462. The estimated maximum area within which PTS could occur in grey and harbour seal is up to 0.001km^2 for the maximum starting hammer energy (500kJ) (Table 12.37).

463. The estimated maximum number of grey seal that could potentially be at risk of PTS as a result of a single strike of the maximum starting hammer energy of 500kJ is 0.000002 grey seal (less than 0.00001% of the reference population or South-east England MU), based on the offshore wind farm area density (0.002/km^2) (Table 12.38). The magnitude of the potential impact is assessed as **negligible**, with less than 0.001% of the reference population anticipated to be exposed to the effect.

464. The estimated number of harbour seal that could potentially be at risk of PTS as a result of a single strike of the maximum starting hammer energy (500kJ), is 0.0000001individuals less than 0.0000001% of the reference population or South-east England MU), based on the offshore wind farm area density (0.0001/km^2) (Table 12.38). The magnitude of the potential impact without any mitigation is assessed as **negligible**, with less than 0.001% of the reference population anticipated to be exposed to the effect.

465. The activation of ADDs, included in the MMMP for piling, prior to the first strike of the soft-start would allow seals to move away prior to the soft start and ramp up, therefore reducing the number of animals within the PTS impact range for the first strike of the soft-start. For example, the activation of ADDs for 10 minutes prior to the soft-start would allow seals to move at least 900m from the piling location (based on a precautionary average marine mammal swimming speed of 1.5m/s), which is beyond the maximum PTS predicted impact range of 0.017km. Therefore after the ADD activation there should be no seals in the potential impact range for PTS from the first strike of the soft-start and therefore with mitigation the potential magnitude would be **negligible**.

Harbour porpoise PTS from single strike at maximum hammer energy

466. The estimated maximum areas (without mitigation) within which PTS could occur in harbour porpoise (Figure 12.5) is estimated to be 19.2km^2 and 9.5km^2 for the maximum hammer energy of the monopile (5,000kJ) and pin-pile (2,7000kJ), respectively (Table 12.37).

467. Without any mitigation, the estimated maximum number of harbour porpoise that could potentially be at risk of PTS as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 24 individuals (0.007% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2) (Table 12.38). The magnitude of the potential impact without any mitigation is assessed as **low**, with between 0.001% and 0.01% of the North Sea MU reference population anticipated to be exposed to the effect without mitigation.

468. The MMMP for piling, including the embedded mitigation, will reduce the risk of PTS from a single strike at the maximum hammer energy by allowing harbour porpoise to move away from the piling location before the maximum hammer energy could be reached, therefore reducing the number of harbour porpoise within the maximum predicted PTS impact range. For example, during the minimum of 10 minutes of ADD activation and a minimum of 30 minutes for the soft-start and ramp-up it is estimated that animals would at least 3.6km from the piling location (based on a precautionary average swimming speed of 1.5m/s), which is greater than the maximum predicted range for PTS of 2.8km for harbour porpoise. As a result, the potential magnitude of effect would be **negligible**.

Pinniped PTS from single strike at maximum hammer energy

469. The estimated maximum areas (without mitigation) within which PTS could occur in grey and harbour seal is up to $0.06km^2$ for the maximum hammer energy of the monopile (5,000kJ) and up to $0.02km^2$ for the maximum hammer energy of the pin-pile (2,700kJ) (Table 12.37).

470. Without any mitigation, the estimated maximum number of grey seal that could potentially be at risk of PTS as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 0.0001 individuals (0.000004% of the reference population or 0.000002% of the South-east England MU) (Table 12.38). The magnitude of the potential impact without any mitigation is assessed as **negligible**, with less than 0.001% of the reference population anticipated to be exposed to the effect.

471. Without any mitigation, the estimated maximum number of harbour seal that could potentially be at risk of PTS as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 0.000006 individuals (less than 0.0000001% of the reference population or the South-east England MU) (Table 12.38). The magnitude of the potential impact without any mitigation is assessed as **negligible**, with less than 0.001% of the reference population anticipated to be exposed to the effect.

472. The MMMP for piling, including the embedded mitigation, will reduce the risk of PTS from a single strike at the maximum hammer energy by allowing seals to move away

from the piling location before the maximum hammer energy could be reached, therefore reducing the number of animals within the potential PTS impact range. For example, as outlined above, during 10 minute ADD activation and the minimum 30 minutes for the soft-start and ramp-up it is estimated that seals and other marine mammals would move at least 3.6km from the piling location (based on a precautionary marine mammal swimming speed of 1.5m/s), which is greater than the maximum range for PTS of 0.16km for seals. The potential magnitude of effect would be **negligible** for harbour and grey seal.

Table 12.38 Maximum number of individuals (and % of reference population) that could be at risk of permanent auditory injury (PTS) from a single strike

			Monopile with maximum hammer energy of 5,000kJ		Pin-pile with maximum hammer energy of 2,700kJ		Starting hammer energy of 500kJ	
Potential Impact	Receptor	Criteria and threshold	Maximum number of individuals (% of reference population)[1] (no mitigation)	Magnitude[2]	Maximum number of individuals (% of reference population)[1] (no mitigation)	Magnitude[2]	Maximum number of individuals (% of reference population)[1]	Magnitude[2]
PTS without mitigation – single strike	Harbour porpoise	NMFS (2016) unweighted SPL_{peak} 202 dB re 1 µPa	17 harbour porpoise (0.005% NS MU) based on SCANS-III survey block O density (0.888/km^2). 24 harbour porpoise (0.007% NS MU) based on site specific survey density (1.26/km^2) at NV East. 15 harbour porpoise (0.004% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Permanent effect with **low** magnitude (between 0.001% and 0.01% of the reference population anticipated to be exposed to effect without mitigation). The MMMP for piling would reduce magnitude to **negligible**.	8 harbour porpoise (0.002% NS MU) based on SCANS-III survey block O density (0.888/km^2). 12 harbour porpoise (0.003% NS MU) based on site specific survey density (1.26/km^2) at NV East. 8 harbour porpoise (0.002% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Permanent effect with **low** magnitude (between 0.001% and 0.01% of the reference population anticipated to be exposed to effect without mitigation). The MMMP for piling would reduce magnitude to **negligible**.	0.5 harbour porpoise (0.0001% NS MU) based on SCANS-III survey block O density (0.888/km^2). 0.8 harbour porpoise (0.0002% NS MU) based on site specific survey density (1.26/km^2) at NV East. 0.5 harbour porpoise (0.0001% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.
PTS without mitigation – single strike	Grey seal	NMFS (2016) unweighted SPL_{peak} 218 dB re 1 µPa	0.0001 grey seal (0.000004% ref pop; 0.000002% SE England MU) based on offshore wind	Permanent effect with **negligible** magnitude (less than 0.001% of	0.00004 grey seal (0.0000002% ref pop; 0.0000007% SE England MU) based on offshore	Permanent effect with **negligible** magnitude (less than 0.001% of reference	0.000002 grey seal (<0.0000001% of ref pop & SE England MU) based on offshore	Permanent effect with '**negligible**' magnitude (less than 0.001% of

Potential Impact	Receptor	Criteria and threshold	Monopile with maximum hammer energy of 5,000kJ		Pin-pile with maximum hammer energy of 2,700kJ		Starting hammer energy of 500kJ	
			Maximum number of individuals (% of reference population)[1] (no mitigation)	Magnitude[2]	Maximum number of individuals (% of reference population)[1] (no mitigation)	Magnitude[2]	Maximum number of individuals (% of reference population)[1]	Magnitude[2]
			farm area density (0.002/km^2).	reference population). The MMMP for piling would ensure **negligible** magnitude.	wind farm area density (0.002/km^2).	population). The MMMP for piling would ensure **negligible** magnitude.	wind farm area density (0.002/km^2).	reference population). The MMMP for piling would ensure **negligible** magnitude.
PTS without mitigation – single strike	Harbour seal	NMFS (2016) unweighted SPL_{peak} 218 dB re 1 µPa	0.000006 harbour seal (<0.0000001% ref pop & SE England MU) based on offshore wind farm area density (0.0001/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.	0.000002 harbour seal (<0.0000001% ref pop & SE England MU) based on offshore wind farm area density (0.0001/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.	0.0000001 harbour seal (<0.0000001% of ref pop & SE England MU) based on offshore wind farm area density (0.0001/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

Harbour porpoise PTS from cumulative exposure

473. This section of the impact assessment considers the risk of PTS from the repeated percussive strikes required to install a single monopile and four pin-piles. The ranges at which an individual could experience PTS are assessed as a result of cumulative exposure during the entire piling duration including the soft-start and ramp-up, based on the animals fleeing at a precautionary average speed of 1.5m/s. The predicted areas for PTS from cumulative SEL ranges for harbour porpoise is estimated to be 0.2km^2 for the maximum hammer energy of 5,000kJ for monopiles and up to 3.4km^2 for pin-piles with maximum hammer energy of 2,700kJ, based on the total duration, including the soft-start and ramp-up, to install four pin-piles for each foundation (Table 12.37).

474. The SEL_{cum} results for harbour porpoise using the NMFS (2016) criteria indicates that the larger hammer hitting a monopile results in lower impact ranges than a smaller hammer hitting a pin-pile. This reflects the hearing sensitivity of harbour porpoise and the sound frequencies produced by the different piles. The noise from pin-piles contains more high frequency components than the noise from monopiles. The overall unweighted noise level is higher for the monopile due to the low frequency components of piling noise (i.e. most of the pile strike energy is in the lower frequencies). The high-frequency cetacean filters, used for harbour porpoise, to determine the weighting used in the criteria, removes the low frequency components of the noise, as these marine mammals are much less sensitive to noise at these frequencies. This leaves the higher frequency noise, which, in the case of the pin-piles, is higher than that for the monopiles (for further details see Appendix 5.3).

475. The indicative maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL as a result of the maximum monopile hammer energy of 5,000kJ is up to 0.25 individuals (0.00007% of the North Sea MU reference population). As a result of the maximum pin-pile hammer energy of 2,700kJ, the estimated maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL is up to 4.3 harbour porpoise (up to 0.001% of the reference population) (Table 12.39). The magnitude of the potential impact is assessed as **low** to **negligible** without mitigation, with up to 0.001% of the reference population anticipated to be exposed to the effect.

476. The implementation of the mitigation measures agreed within the MMMP for piling will reduce the risk of PTS in harbour porpoise, as the mitigation zone will ensure they are out with the range for PTS. For example, as outlined above, during the ADD activation for a minimum of 10 minutes and a minimum 30 minutes for the soft-start and ramp-up, it is estimated that animals would move at least 3.6km from the piling

location (based on a precautionary average marine mammal swimming speed of 1.5m/s), which is greater than the maximum predicted range for PTS SEL_{cum} of 1.5km. As a result, the potential magnitude of effect would be **negligible**.

Pinniped PTS from cumulative exposure

477. For grey and harbour seals, the maximum potential impact areas for PTS from cumulative SEL is 13.64km^2 for the maximum hammer energy of 5,000kJ for monopiles and 5.3km^2 for the maximum hammer energy of 2,700kJ for pin-piles. This is based on the total piling duration for a single monopile (including the soft-start and ramp-up) and total duration to install four pin-piles per foundation (including the soft-start and ramp-up) and the animals fleeing at a precautionary average speed of 1.5m/s (Table 12.37).

478. The indicative maximum number of grey seal that could potentially be at risk of PTS from cumulative SEL as a result of the maximum monopile hammer energy of 5,000kJ is 0.03 grey seal (0.0001% of the reference population or 0.0005% of the South-east England MU) or for maximum pin-pile hammer energy of 2,700kJ is 0.01 grey seal (0.00004% of the reference population or 0.0002% South-east England MU) (Table 12.39). The magnitude of the potential impact is assessed as **negligible** with less than 0.001% of the reference population anticipated to be exposed to effect. In addition, taking into account the time seals spend at the surface and with their head out of the water (as outlined below) the magnitude would be **negligible**.

479. The indicative maximum number of harbour seal that could potentially be at risk of PTS from cumulative SEL as a result of the maximum monopile hammer energy of 5,000kJ is 0.001 harbour seal (0.000002% of the reference population or 0.00002% of the South-east England MU) or for the maximum pin-pile hammer energy of 2,700kJ is 0.0005 individuals (0.000001% of the reference population or 0.00001% of the South-east England MU) (Table 12.39). The magnitude of the potential impact is assessed as **negligible**, with less than 0.001% of the reference population anticipated to be exposed to the effect. Again, taking into account the time seals spend at the surface and with their head out of the water (as outlined below) the magnitude would be **negligible**.

480. The implementation of the mitigation measures agreed within the MMMP for piling would reduce the risk of PTS in seals, as the mitigation zone will ensure they are out with the range for PTS. For example, as outlined above, during the ADD activation for a minimum of 10 minutes and a minimum 30 minutes for the soft-start and ramp-up it is estimated that animals would move over 3.6km from the piling location (based on a precautionary average marine mammal swimming speed of 1.5m/s), which is greater than the maximum predicted range for PTS SEL_{cum} of 2.4km. As a result, the potential magnitude of effect would be **negligible**.

Considerations of the risk of PTS from cumulative SEL

481. The risk of PTS from cumulative SEL ranges indicate the distance that an individual animal needs to be from the noise source at the onset of the piling sequence to prevent a cumulative noise exposure which could lead to PTS. It should be noted that this assessment is highly precautionary for the following reasons:

- The maximum impact ranges provided in Appendix 5.3, based on the worst case exposure levels an animal may receive at different depths in the water column, have been used in the assessment, this is highly conservative as it is unlikely a marine mammal would remain at this depth level;
- The assessment does not take account of periods where exposure will be reduced when they are at the surface or heads are out of the water; and
- The cumulative noise dose received by the marine mammal will be largely dependent on the swimming speed, and whether the animal moves away from the noise source rapidly as a flee response. For the SEL_{cum} noise modelling the swim speed of 1.5m/s used is highly conservative and therefore this is likely to overestimate the received noise levels, especially for seals, as they are likely to have their heads out of the water most of the time.

Table 12.39 Indicative maximum number of individuals (and % of reference population) that could be at risk of PTS from cumulative exposure

Potential Impact	Receptor	Criteria and threshold	Maximum number of individuals (% of reference population)[1] Monopile with maximum hammer energy of 5,000kJ	Magnitude[2]	Pin-pile with maximum hammer energy of 2,700kJ	Magnitude[2]
PTS – cumulative exposure (including soft-start and ramp-up)	Harbour porpoise	NMFS (2016) SEL_{cum} Weighted 155 dB re 1 μPa^2s	0.2 harbour porpoise (0.00006% of NS MU) based on SCANS-III survey block O density (0.888/km^2). 0.25 harbour porpoise (0.00007% of NS MU) based on site specific survey density (1.26/km^2) at NV East. 0.16 harbour porpoise (0.00005% of NS MU) based on site specific survey density (0.79/km^2) at NV West.	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.	3 harbour porpoise (0.0009% of NS MU) based on SCANS-III survey block O density (0.888/km^2). 4.3 harbour porpoise (up to 0.001% NS MU) based on site specific survey density (1.26/km^2) at NV East. 2.7 harbour porpoise (0.0008% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Permanent effect with **negligible** to **low** magnitude (less than 0.001% of reference population). The MMMP for piling would reduce magnitude to **negligible**.
PTS – cumulative exposure (including soft-start and ramp-up)	Grey seal	NMFS (2016) SEL_{cum} Weighted 185 dB re 1 μPa^2s	0.03 grey seal (0.0001% ref pop; 0.0005% SE England MU) based on offshore wind farm area density (0.002/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.	0.01 grey seal (0.00004% ref pop; 0.0002% SE England MU) based on offshore wind farm area density (0.002/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.

Potential Impact	Receptor	Criteria and threshold	Maximum number of individuals (% of reference population)[1] Monopile with maximum hammer energy of 5,000kJ	Magnitude[2]	Pin-pile with maximum hammer energy of 2,700kJ	Magnitude[2]
PTS – cumulative exposure (including soft-start and ramp-up)	Harbour seal	NMFS (2016) SEL_{cum} Weighted 185 dB re 1 µPa^{2}s	0.001 harbour seal (0.000002% ref pop; 0.00002% SE England MU) based on offshore wind farm area density (0.0001/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.	0.0005 harbour seal (0.000001% ref pop; 0.00001% SE England MU) based on offshore wind farm area density (0.0001/km^2).	Permanent effect with **negligible** magnitude (less than 0.001% of reference population). The MMMP for piling would ensure **negligible** magnitude.

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

Permanent auditory injury impact significance

482. Taking into account the receptor sensitivity and the potential magnitude of the effect (i.e. number of individuals as a percentage of the reference population) and the embedded mitigation, the impact significance for any permanent auditory injury in harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant) (Table 12.40).

Mitigation

483. The MMMP for piling will be developed post-consent in consultation with SNCBs and will be based on the latest information, scientific understanding and guidance and detailed project design. The MMMP will detail the proposed mitigation measures to reduce the risk of any permanent auditory injury (PTS) to marine mammals as a result of underwater noise during piling.

484. The MMMP for piling will be developed in consultation with the relevant SNCBs and the MMO, detailing the proposed mitigation measures to reduce the risk of any physical or permanent auditory injury (PTS) to marine mammals during all piling operations. This will include details of the embedded mitigation, for the soft-start, ramp-up and mitigation zone in order to minimise potential impacts on physical and auditory injury, as well as details of any additional mitigation that could be required, for example, the activation of acoustic deterrent devices (ADDs) prior to the soft-start.

485. A draft MMMP for piling (document reference 8.13) is submitted with the DCO Application.

Residual impact

486. The residual impact of the potential risk of permanent auditory injury (PTS) to marine mammals as a result of underwater noise during piling will be reduced to a negligible magnitude taking into account the mitigation in the MMMP for piling to reduce the potential effects. Therefore, with high sensitivity the potential impact significance for any permanent auditory injury, will be **minor adverse** (not significant) (Table 12.40).

Table 12.40 Assessment of impact significance for any permanent auditory injury (PTS) in marine mammals from underwater noise during piling

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Permanent auditory injury (PTS) injury as a result of underwater noise from single strike of starting	Harbour porpoise, grey seal and harbour	High	Negligible	Minor adverse	MMMP	**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
hammer energy	seal					
Permanent auditory injury (PTS) injury as a result of underwater noise from single strike of maximum hammer energy	Harbour porpoise	High	Negligible (without embedded mitigation)	Minor adverse	MMMP including embedded mitigation	**Minor adverse**
	Grey seal and harbour seal	High	Negligible (without embedded mitigation)	Minor adverse		
Permanent auditory injury (PTS) injury as a result of underwater noise during piling from cumulative exposure	Harbour porpoise	High	Low to negligible (without mitigation)	Moderate to Minor	MMMP including embedded mitigation	**Minor adverse**
	Grey seal and harbour seal	High	Negligible (without mitigation)	Minor adverse		

12.7.4.2.3 Temporary auditory injury and fleeing response

Temporary auditory injury and fleeing response sensitivity

487. Harbour porpoise, grey seal and harbour seal are assessed as having **medium** sensitivity to TTS onset (Table 12.36). The sensitivity of each receptor to TTS onset is the assumed to be the same as fleeing response / likely avoidance.

Temporary auditory injury and fleeing response magnitude

488. The underwater noise modelling results for the maximum predicted ranges (and areas) for temporary auditory injury (TTS) and fleeing response in harbour porpoise, grey seal and harbour seal are presented in (Table 12.41) for:

- Monopile with maximum hammer energy of 5,000kJ; and
- Pin-pile with maximum hammer energy of 2,700kJ.

489. Based on:

- The NOAA (NMFS, 2016) criteria for unweighted SPL_{peak} and TTS from cumulative SEL (SEL_{cum}).

490. For harbour porpoise, grey seal and harbour seal a fleeing response is assumed to occur at the same noise levels as TTS and the potential impact is also described as ‘likely avoidance of area’. The response of individuals to a noise stimulus will vary and not all individuals will respond, however, for the purpose of this assessment, it is

assumed that at the ‘likely avoidance’ range 100% of the individuals exposed to the noise stimulus will respond and flee the area.

Table 12.41 Maximum predicted impact ranges (and areas) for TTS / fleeing response from a single strike and for TTS from cumulative exposure

Potential Impact	Receptor	Criteria and threshold	Maximum predicted impact range (km) and area (km^2)	
			Monopile with maximum hammer energy of 5,000kJ	Pin-pile with maximum hammer energy of 2,700kJ
TTS and fleeing response without mitigation – single strike	Harbour porpoise	NMFS (2016) unweighted SPL_{peak} 196 dB re 1 µPa	5.7km ($88km^2$)	4.2km ($44km^2$)
	Grey seal and harbour seal	NMFS (2016) unweighted SPL_{peak} 212 dB re 1 µPa	0.54km ($0.7km^2$)	0.32km ($0.2km^2$)
TTS from cumulative SEL	Harbour porpoise	NMFS (2016) SEL_{cum} Weighted 140 dB re 1 $µPa^2s$	7.4km ($137.7km^2$)*	11km ($896.6km^2$)*
	Grey seal and harbour seal	NMFS (2016) SEL_{cum} Weighted 170 dB re 1 $µPa^2s$	21km ($247.2km^2$)*	17km ($628.9km^2$)*

*Area for TTS SEL_{cum} based on area of circle not modelled impact area

<u>Harbour porpoise TTS / fleeing response from single strike at maximum hammer energy</u>

491. The risk of TTS / fleeing response from a single strike of maximum hammer energy is significantly reduced through embedded mitigation as the maximum hammer energy strike would always be preceded by the soft-start and ramp-up and other mitigation measures (for example, the activation of ADDs).

492. The estimated maximum ranges for TTS / fleeing response in harbour porpoise, is estimated to be 5.7km and 4.2km for the maximum hammer energy of the monopile (5,000kJ) and pin-pile (2,7000kJ), respectively (Figure 12.6; Table 12.41).

493. The estimated maximum number of harbour porpoise that could potentially be at risk of TTS / fleeing response as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 111 individuals (0.03% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2) (Table 12.42). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

494. The implementation of the MMMP for piling would reduce the risk of TTS from a single strike at the maximum hammer energy by allowing harbour porpoise to move away, therefore reducing the number of harbour porpoise within the potential TTS impact range. For example, as outlined above, during the activation of ADDs for 10 minutes and the minimum of 30 minutes for the soft-start and ramp-up it is estimated that animals would move 3.6km from the piling location (based on a precautionary average marine mammal swimming speed of 1.5m/s). The number of harbour porpoise predicted to be in the TTS range after ADD activation, the soft-start and ramp-up would be 60 individuals (0.02% of the North Sea MU reference population) based on 111 individuals minus 51 harbour porpoise in 40.7km^2 area with radius of 3.6km. Therefore, the magnitude of the potential impact is assessed as **negligible**.

Pinniped TTS / fleeing response from single strike at maximum hammer energy

495. The estimated maximum ranges within which TTS / fleeing response could occur in grey and harbour seal is up to 0.54km for the maximum hammer energy of the monopile (5,000kJ) and up to 0.32km for the maximum hammer energy of the pin-pile (2,7000kJ) (Figure 12.7; Table 12.41).

496. The estimated maximum number of grey seal that could potentially be at risk of TTS /fleeing response as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 0.001 individuals (0.000005% of the reference population or 0.00002% of the South-east England MU). Or as a result of a single strike of the maximum pin-pile hammer energy of 2,700kJ is 0.0004 individuals (0.000002% of the reference population or 0.000007% of the South-east England MU), based on the offshore wind farm area density (0.002/km^2) (Table 12.42). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

497. The estimated maximum number of harbour seal that could potentially be at risk of TTS / fleeing response as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is 0.00007 individuals (0.0000002% of the reference population or 0.000001% of the South-east England MU). Or as a result of a single strike of the maximum pin-pile hammer energy of 2,700kJ is 0.00002 individuals (0.00000005% of the reference population or 0.0000004% of the South-east England MU), based on the offshore wind farm area density (0.0001/km^2) (Table 12.42). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

498. The implementation of the MMMP for piling would reduce the risk of TTS from a single strike at the maximum hammer energy by allowing seals to move away, therefore reducing the number of animals within the potential TTS impact range.

For example, as outlined above, during the activation of ADDs for 10 minutes, the minimum of 30 minutes for the soft-start and ramp-up it is estimated that animals would move 3.6km from the piling location (based on a precautionary average marine mammal swimming speed of 1.5m/s). This is greater than the maximum range for TTS in seals and therefore the potential magnitude of effect would be **negligible** for harbour and grey seal.

Table 12.42 Maximum number of individuals (and % of reference population) that could be at risk of temporary auditory injury (TTS) / fleeing response from a single strike

Potential Impact	Receptor	Criteria and threshold	Maximum number of individuals (% of reference population)[1]			
			Monopile with maximum hammer energy of 5,000kJ	Magnitude[2]	Pin-pile with maximum hammer energy of 2,700kJ	Magnitude[2]
TTS / fleeing response – single strike	Harbour porpoise	NMFS (2016) unweighted SPL_{peak} 196 dB re 1 µPa	78 harbour porpoise (0.02% NS MU) based on SCANS-III survey block O density (0.888/km^2). 111 harbour porpoise (0.03% NS MU) based on site specific survey density (1.26/km^2) at NV East. 70 harbour porpoise (0.02% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Temporary effect with **negligible** magnitude (less than 1% of reference population).	39 harbour porpoise (0.01% NS MU) based on SCANS-III survey block O density (0.888/km^2). 55 harbour porpoise (0.02% NS MU) based on site specific survey density (1.26/km^2) at NV East. 35 harbour porpoise (0.01% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Temporary effect with **negligible** magnitude (less than 1% of reference population).
TTS / fleeing response – single strike	Grey seal	NMFS (2016) unweighted SPL_{peak} 212 dB re 1 µPa	0.001 grey seal (0.0000045% ref pop; 0.00002% SE England MU) based on offshore wind farm area density (0.002/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).	0.0004 grey seal (0.000002% ref pop; 0.000007% of SE England MU) based on offshore wind farm area density (0.002/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).
TTS / fleeing response – single strike	Harbour seal	NMFS (2016) unweighted SPL_{peak} 212 dB re 1 µPa	0.00007 harbour seal (0.0000002% ref pop; 0.000001% of SE England MU) based on offshore wind farm area density (0.0001/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).	0.00002 harbour seal (0.00000005% ref pop; 0.0000004% of SE England MU) based on offshore wind farm area density (0.0001/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

Harbour porpoise TTS / fleeing response from cumulative exposure

499. The ranges at which an individual could experience TTS / fleeing response as a result of cumulative exposure during the total piling duration , including the soft-start and ramp-up, based on the SEL_{cum} noise modelling using animals fleeing at a speed of 1.5m/s, but not taking into account any preceding mitigation, such as ADD activation, is estimated to be 7.4km and 11km for harbour porpoise for the maximum hammer energies of 5,000kJ for monopiles and 2,700kJ for pin-piles, respectively, based on the NOAA (NMFS, 2016) criteria (Table 12.41).

500. Without any mitigation preceding the soft-start and ramp-up, the indicative maximum number of harbour porpoise that could potentially be at risk of TTS / fleeing response from cumulative SEL as a result of the maximum monopile hammer energy of 5,000kJ is up to 174 individuals (0.05% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2) (Table 12.43). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

501. For pin-piles with maximum hammer energy of 2,700kJ and based on the duration to install four pin-piles for each foundation, including soft-start and ramp-up, the indicative maximum number of harbour porpoise that could potentially be at risk of TTS / fleeing response from cumulative SEL is up to 1,130 harbour porpoise (0.3% of the North Sea MU reference population) based on site specific survey density (1.26/km2) at NV East (Table 12.43). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

502. The implementation of the MMMP for piling would reduce the risk of cumulative TTS, for example by the implementation of ADDs, allowing harbour porpoise to move away from the pile location, therefore reducing the number of individuals within the potential TTS impact range. Therefore, the magnitude of the potential impact is assessed as **negligible**.

Pinniped TTS / fleeing response from cumulative exposure

503. For grey and harbour seals, the maximum potential impact ranges for TTS / fleeing response from cumulative SEL is 21km for the maximum hammer energy of 5,000kJ for monopiles and 17kmkm the maximum hammer energy of 2,700kJ for pin-piles (Table 12.41).

504. The indicative maximum number of grey seal that could potentially be at risk of TTS / fleeing response from cumulative SEL, without mitigation preceding the soft-start and ramp-up, as a result of the maximum monopile hammer energy of 5,000kJ is 0.5

grey seal (0.002% of the reference population or 0.008% of the South-east England MU) or 1.3 grey seal (0.006% of the reference population or 0.02% of the South-east England MU) for the maximum pin-pile hammer energy of 2,700kJ, based on the offshore wind farm area density (0.002/km^2) (Table 12.43). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

505. The indicative maximum number of harbour seal that could potentially be at risk of TTS from cumulative SEL, without mitigation preceding the soft-start and ramp-up, as a result of the maximum monopile hammer energy of 5,000kJ is 0.025 individuals (0.00005% of the reference population or 0.0004% of the South-east England MU) or 0.06 harbour seal (0.0001% of the reference population or 0.001% of the South-east England MU) for the maximum pin-pile hammer energy of 2,700kJ, based on the offshore wind farm area density (0.0001/km^2) (Table 12.43). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

506. The implementation of the MMMP for piling would reduce the risk of cumulative TTS, for example by the implementation of ADDs, allowing seals to move away from the piling location, therefore reducing the number of individuals within the potential TTS impact range. Therefore, the magnitude of the potential impact is assessed as **negligible**.

Considerations of the risk of TTS from cumulative exposure

507. As outlined for PTS from cumulative exposure, the ranges indicate the distance that an individual needs to be from the noise source at the onset of the piling sequence to prevent a cumulative noise exposure which could lead to TTS. However, this type of assessment is completed for information purposes only, as discussed in section 12.7.4.2.2 this is highly conservative because the assessment assumes the worst-case exposure levels for an animal in the water column, and does not take account of periods where exposure will be reduced in seals when their heads are out of the water; or that the cumulative noise dose received by the marine mammal will be largely dependent on the swimming speed, and whether the animal moves away from the noise source rapidly as a flee response. The cumulative SEL dose does not take account of this and therefore is likely to overestimate the received noise levels.

Table 12.43 Indicative maximum number of individuals (and % of reference population) that could be at risk of TTS from cumulative exposure

Potential Impact	Receptor	Criteria and threshold	Maximum number of individuals (% of reference population)[1]			
			Monopile with maximum hammer energy of 5,000kJ	Magnitude[2]	Pin-pile with maximum hammer energy of 2,700kJ	Magnitude[2]
TTS / fleeing response without mitigation – cumulative exposure	Harbour porpoise	NMFS (2016) SEL_{cum} Weighted 140 dB re 1 µPa^{2}s	122 harbour porpoise (0.04% NS MU) based on SCANS-III survey block O density (0.888/km^2). 174 harbour porpoise (0.05% NS MU) based on site specific survey density (1.26/km^2) at NV East. 109 harbour porpoise (0.03% NS MU) based on site specific survey density (0.79/km^2) at NV West.	Temporary effect with **negligible** magnitude (less than 1% of reference population).	796 harbour porpoise (0.2% NS MU) based on SCANS-III survey block O density (0.888/km^2). 1,130 harbour porpoise (0.3% NS MU) based on site specific survey density (1.26/km^2) at NV East. 708 harbour porpoise (0.2% NS MU) based on site specific survey density (0.74/km^2) at NV West.	Temporary effect with **negligible** magnitude (less than 1% of reference population).
	Grey seal	NMFS (2016) SEL_{cum} Weighted 170 dB re 1 µPa^{2}s	0.5 grey seal (0.002% ref pop; 0.008% SE England MU) based on offshore wind farm area density (0.002/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).	1.3 grey seal (0.006% ref pop; 0.02% SE England MU) based on offshore wind farm area density (0.002/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).
	Harbour seal	NMFS (2016) SEL_{cum} Weighted 170 dB re 1 µPa^{2}s	0.02 harbour seal (0.00005% ref pop; 0.0004% SE England MU) based on offshore wind farm area density (0.0001/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).	0.06 harbour seal (0.0001% ref pop; 0.001% of SE England MU) based on offshore wind farm area density (0.0001/km^2).	Temporary effect with **negligible** magnitude (less than 1% of reference population).

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

Temporary auditory injury and fleeing response impact significance

508. Taking into account the receptor sensitivity and the potential magnitude of the temporary impact (e.g. number of individuals as a percentage of the reference population), the impact significance for any temporary auditory injury (TTS) and fleeing response in harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant) (Table 12.44).

Mitigation

509. The MMMP for piling will be produced post-consent in consultation with SNCBs and will be based on the latest scientific understanding and guidance and detailed project design. The MMMP for piling will detail the proposed mitigation measures to reduce the risk of any permanent auditory injury (PTS) to marine mammals as a result of underwater noise during piling. The mitigation to reduce the risk of PTS will move animals away from the piling location and will therefore also reduce the number of animals in the predicted impact area for TTS.

Residual impact

510. The residual impact of the potential risk of temporary auditory injury (TTS) to marine mammals as a result of underwater noise during piling will be reduced to a negligible magnitude taking into account the MMMP for piling, including embedded mitigation, therefore with medium sensitivity the potential impact significance for any temporary auditory injury, it is expected that the overall impact significance will be **minor adverse** (not significant) (Table 12.44).

Table 12.44 Assessment of impact significance for underwater noise during piling on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Temporary auditory injury (TTS) and fleeing response as a result of underwater noise from single strike of maximum hammer energy	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse	MMMP including embedded mitigation	**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Temporary auditory injury (TTS) and fleeing response as a result of underwater noise during piling from cumulative exposure	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse		

12.7.4.2.4 Disturbance

Disturbance sensitivity

511. Harbour porpoise have relatively high daily energy demands and need to consume between 4% and 9.5% of their body weight in food per day (Kastelein *et al*., 1997). If a harbour porpoise does not capture enough prey to meet its daily energy requirements it can rely on stored energy (primarily blubber) for an estimated three to five days, depending on body condition (Kastelein *et al*., 1997). Should harbour porpoise be excluded from an area of key prey resource it will likely seek an alternative food resource and this could have an effect on the individual's fitness. For example, they may have to travel further or take less than optimum prey species. The effects on an individual's fitness are partly caused by the exclusion of animals from high-quality foraging areas and partly by the net energy losses associated with fleeing from disturbances (Nabe-Nielsen *et al*., 2014). Therefore, impacts in lower quality habitat are likely to have a lower potential impact on an animal's fitness.

512. A study by Wisniewska *et al*. (2016) using high-resolution movement and prey echo recording tags on five wild harbour porpoise has shown that porpoises forage nearly continuously day and night, attempting to meet their metabolic demands foraging on small prey. Harbour porpoise are assessed as having **medium** sensitivity to disturbance (Table 12.36).

513. Harbour seal and grey seal exhibit alternate periods of foraging and resting at haul out sites (during which limited or no feeding occurs). Prolonged fasting also occurs in these species during annual breeding and moult, when there are marked seasonal changes in body condition (Rosen and Renouf, 1997; Bäcklin *et al*., 2011). Although adult seals may be relatively robust to short term (weeks rather than days compared to harbour porpoise) changes in prey availability, young and small individuals have a more sensitive energy balance. This is exhibited through effects of mass dependant survival (Harding *et al*., 2005). Although disturbance to harbour or grey seal may

lead to a severe or sustained avoidance of an area, these species can be considered less sensitive to such an impact than harbour porpoise. Tagged harbour seals in the Wash indicated that seals were not excluded from the vicinity of the windfarm during the overall construction phase but that there was clear evidence of avoidance during pile driving, with significantly reduced levels of seal activity at ranges up to 25km from piling sites (Russell *et al*., 2016). However, within two hours of cessation seal distribution returned to pre-piling levels (Russell *et al*., 2016). However, as a precautionary approach, harbour and grey seal are also assessed as having **medium** sensitivity to disturbance (Table 12.36).

514. The sensitivity of marine mammals to disturbance is considered to be **medium** in this assessment as a precautionary approach. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects, although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased.

Disturbance magnitude

515. For harbour porpoise, grey seal and harbour seal, a fleeing response is assumed to occur at the same noise levels as TTS. Therefore, the potential range and areas for 'fleeing response / likely avoidance' in harbour porpoise, grey seal and harbour seal are presented in Table 12.41, with the estimated number and percentage of reference populations in Table 12.42. The response of individuals to a noise stimulus will vary and not all individuals will respond; however, for the purpose of this assessment, it is assumed that at the 'likely avoidance' range, 100% of the individuals exposed to the noise stimulus will respond and flee the area.

Disturbance during proposed mitigation

516. Although the proposed mitigation would increase the distance of marine mammals from the piling location, it cannot mitigate the potential disturbance to marine mammals.

517. During the implementation of the proposed mitigation, for example the activation of ADDs for 10 minutes and the minimum 30 minutes for the soft-start and ramp-up it is estimated that animals would move at lease 3.6km (2.7km for 30 minute soft-start and ramp-up plus 0.9km during ADD activation for 10 minutes) from the piling location (based on a precautionary marine mammal swimming speed of 1.5m/s), an area of 41km^2.

518. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation would be 73 individuals (0.02% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2) as a worst-case scenario. Therefore, the magnitude of the

potential temporary impact is assessed as **negligible**. Less than 1% of the reference population would be temporarily exposed to the effect.

519. The number of grey seal that could potentially be disturbed as a result of the proposed mitigation would be 0.1 individuals (0.00045% of the reference population or 0.002% of the South-east England MU). Therefore, the magnitude of the potential temporary impact is assessed as **negligible**.

520. The number of harbour seal that could potentially be disturbed as a result of the proposed mitigation would be 0.006 individuals (0.00001% of the reference population or 0.0001% of the South-east England MU). Therefore, the magnitude of the potential temporary impact is assessed as **negligible**.

521. For two concurrent piling installations (either two in NV West or two in NV East or one in each site), if both were starting piling at the same time, the potential area of disturbance as a result of the proposed mitigation would be 116km^2. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation for two concurrent piling location would be 146 individuals (0.04% of the North Sea MU reference population), based on the site specific density for NV East (1.26 harbour porpoise per km^2). Therefore, the magnitude of the potential temporary impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the effect. The magnitude would also be **negligible** for grey and harbour seals.

522. For two concurrent piling installations, the number of grey seal and harbour seal that could potentially be disturbed as a result of the proposed mitigation would be 0.2 grey seal (0.0009% of the reference population or 0.003% of the South-east England MU) and 0.01 harbour seal (0.00002% of the reference population or 0.0002% of the South-east England MU). Therefore, the magnitude of the potential temporary impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the effect. The magnitude would also be **negligible** for grey and harbour seals.

523. It should be noted that the disturbance as a result of the proposed mitigation prior to piling would be part of the 26km disturbance range for piling and is therefore not an additive effect to the overall area of potential disturbance. However, the duration of the proposed mitigation prior to piling has been taken into account, as a worst-case scenario, in the assessment of the duration of potential disturbance.

<u>Disturbance during single pile installation</u>

524. The current advice from the SNCBs is that a potential disturbance range of 26km (approximate area of 2,124km^2) around piling locations is used to assess the area

that harbour porpoise may be disturbed in the Southern North Sea (SNS) cSAC. Norfolk Vanguard is located within the SNS cSAC therefore this approach has been used for the EIA as well as the assessments for the HRA. The estimated number of harbour porpoise that could be disturbed as a result of underwater noise during piling is presented in Table 12.45.

525. As outlined above, tagged harbour seals in the Wash indicated that seals were not excluded from the vicinity of the windfarm during the overall construction phase but that there was clear evidence of avoidance during pile driving, with significantly reduced levels of seal activity at ranges up to 25km from piling sites (Russell *et al.,* 2016; SCOS, 2016, 2017). Therefore, the 26km disturbance range has also been used for grey and harbour seals to be consistent with harbour porpoise range (Figure 12.7; Table 12.45). It is acknowledged that this is not Natural England's advice, however this approach was agreed by the ETG as part of the EPP.

526. The estimated maximum number of harbour porpoise that could potentially be disturbed as a result of underwater noise from piling is 2,676 individuals (0.8% of the North Sea MU reference population), based on all porpoises in 2,124km^2 area being disturbed and the site specific density for NV East (1.26 harbour porpoise per km^2) (Table 12.45). The magnitude of the potential effect is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

527. The estimated maximum number of grey seals that could potentially be disturbed as a result of underwater noise from piling is four grey seals (0.002% of the reference population or 0.07% of the South-east England MU; Table 12.45). The magnitude of the potential effect is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

528. The estimated maximum number of harbour seals that could potentially be disturbed as a result of underwater noise from piling is 0.2 individuals (0.00005% of the reference population or 0.004% of the South-east England MU; Table 12.45). The magnitude of the potential effect is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

529. The maximum total piling duration for the installation would be up to 1,200 hours for 200 9MW turbines (Table 12.24) plus an estimated maximum of 133 hours for 10 minute ADD activation per pile, based on worst-case scenario of up to 800 pin-piles, resulting in approximately 1,333 hours of disturbance. In addition, piling for the eight offshore platforms would be up to 60 hours (Table 12.24) plus an estimated six hours for 10 minute ADD activation per pile for the 34 piles. Therefore, the

maximum piling duration (including ADD activation) for Norfolk Vanguard would be up to 1,399 hours (equivalent of up to 58 days).

530. Indicative installation worst-case scenarios (Table 12.24) for the different phasing options include:

- Single phase – up to 200 wind turbine foundations (either 200 monopiles or 800 pin-piles for 9MW turbines) and eight offshore platforms (up to 34 piles) in the 20 month foundation installation period of the 23 months for overall construction; or
- Two phase – up to 100 wind turbine foundations (either 100 monopiles or 400 pin-piles for 9MW turbines) as well as four offshore platforms (up to 17 piles) in each of the two 8 month foundation installation periods and 12 months for construction in each phase.

531. Phases could either be constructed consecutively, condensing the overall construction programme (similar to that of a single phased installation) or could require gaps of a number of years between each phase, up to an overall construction programme of approximately four years. Under the latter scenario marine mammals would be expected to return in between construction phases (see estimated return times of harbour porpoise after piling events, outlined below).

532. In addition, piling would not be constant during the piling phases and construction periods. There will be gaps between the installations of individual piles, and if installed in groups there could be time periods when piling is not taking place as piles are brought out to the site. There will also be potential delays for weather or other technical issues.

533. The duration of piling is based on a worst-case scenario and a very precautionary approach and as has been shown at other offshore wind farms the duration used in the impact assessment can be overestimated. For example, during the installation of monopile foundations at the Dudgeon Offshore Wind Farm (DOW) the impact assessment was based on an estimated piling period of 93 days, time to install each monopile was estimated to be up to 4.5 hours and the estimated duration of active piling was 301.5 hours (approximately 13 days). However, the actual total duration of active piling to install the 67 monopiles was 65 hours (approximately 3 days) with the average time for installation per monopile of 71 minutes (DOWL, 2016). Therefore, the actual piling duration was approximately 21% of the predicated maximum piling duration. The piling duration to install the individual monopiles at DOW varied considerably for each location and worst-case scenario of up to 4.5 hours to install a pile was an accurate assessment of the actual maximum duration (4.35 hours), however the majority of piles were installed in a lot shorter duration.

At DOW the time intervals between the installations of individual monopiles, not including the intervals between groups of monopiles was on average approximately 23 hours. Monopiles were installed in groups of up to three due to the capacity of the piling vessel, which meant that it could only carry three monopiles and three transition pieces before returning to port to collect the next three monopiles. The intervals between groups of monopiles being installed ranged from approximately 2.5 days to 11 days with an average of approximately four days between the 22 groups of three monopiles (DOWL, 2016).

534. It is possible that a behavioural disturbance from a single pile driving event could be sufficient to exclude harbour porpoise from the area around the noise source for several days (Thomsen *et al*., 2006; Brandt *et al*., 2009; 2011; Thompson *et al*. 2010b). However, studies at the Borkum West II project in Germany that deployed a large bubble curtain during monopile installation reported on average (median) a significant displacement effect was detectable until 9 to 12 hours after pile driving activity. Detection rates were lowest until four hours after pile driving and increased gradually afterwards (Diederichs *et al*., 2014).

535. The duration of the exclusion could last up to three days following a single piling event if the animal is close to the source. Data presented by Brandt *et al*. (2009, 2011) indicated that harbour porpoise would completely leave the area (indicated by the duration of waiting time between porpoise detections after first piling) for a median time of 16.6 hours and a maximum of 74.2 hours within 0.5-6km of the noise source. Waiting times did not return to 'normal' until 22.7 hours after piling. At distances of greater than approximately 9km from the noise source there was a much shorter duration of effect; with waiting times returning to 'normal' between one and 2.6 hours after piling ceased. However, at 18-25km there was still a marked effect. Porpoise activity (measured by the number of minutes per hour in which porpoise were detected expressed as porpoise positive minutes) was significantly lower within approximately 3km of the noise source for 40 hours after piling.

536. A study on the effects of the construction of offshore wind farms within the German North Sea between 2009 and 2013 on harbour porpoise (Brandt *et al*., 2016), indicated that the effect on duration after piling was about 20-31 hours at the close vicinity of the construction site (up to 2km) and decreased with increasing distance. Project-specific estimates ranged between 16 and 46 hours. The study also observed significant decreases in porpoise detections prior to piling at distances of up to 10km, which is thought to relate to increased shipping activity during preparation works. The study concluded that although there were clear negative short-term effects (1-2 days in duration) of offshore wind farm construction (some with sound mitigation techniques) on acoustic porpoise detections and densities, there is

currently no indication that harbour porpoises within the German Bight are presently negatively affected by wind farm construction at the population level (Brandt *et al.*, 2016).

537. The duration of any potential displacement effect will differ depending on the distance of the individual from the piling activity and the noise level the animal is exposed to. Furthermore, for those individuals distant from the activity and which therefore did not respond and were not affected, they will continue with their normal behaviour that may involve approaching the wind farm area.

Table 12.45 Estimated number of harbour porpoise, grey seal and harbour seal potentially disturbed during piling based on 26km range from piling location

Potential Impact	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
Area of disturbance (2,124km^2) from underwater noise during piling	Harbour porpoise	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.6% of NS MU based on SCANS-III density. 0.8% of NS MU based on site specific survey density at NV East. 0.5% of NS MU based on site specific survey density at NV West.	Temporary effect with '**negligible**' magnitude (less than 1% of reference population).
	Grey seal	4 grey seal based on offshore wind farm area density (0.002/km^2).	0.02% ref pop (0.07% SE England MU)	Temporary effect with '**negligible**' magnitude.
	Harbour seal	0.2 harbour seal based on offshore wind farm area density (0.0001/km^2).	0.0005% ref pop (0.004% SE England MU)	Temporary effect with '**negligible**' magnitude.

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

<u>Disturbance during concurrent piling</u>

538. The maximum potential area of disturbance, based on 26km range (area of 2,124km^2 around each piling location), has been estimated for the worst-case concurrent piling scenarios (e.g. maximum distance between piling vessels and least amount of overlap in potential impact areas, see Figure 12.8) for:

- Two concurrent piling events in NV West (3,520km^2);
- Two concurrent piling events in NV East (3,508km^2); and
- Two concurrent piling events based on one worst-case location in NV East and one worst-case location NV West (4,248km^2).

539. The spatial worst-case is the maximum area (4,248km^2) over which displacement could occur at any one time based on four concurrent foundations being installed (Table 12.46; Figure 12.8).

540. The estimated maximum number of harbour porpoise that could potentially be temporarily disturbed as a result of underwater noise from concurrent piling is 1.3% of the North Sea MU reference population (Table 12.46), based on the worst-case scenario. The magnitude of the potential effect is assessed as **low**, with between 1% and 5% of the reference population anticipated to be exposed to the temporary effect.

541. The estimated maximum number of grey seal that could potentially be disturbed as a result of underwater noise from concurrent piling is 0.04% of the reference population or 0.1% of the South-east England MU; Table 12.46). The magnitude of the potential effect is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

542. The estimated maximum number of harbour seal that could potentially be disturbed as a result of underwater noise from concurrent piling is 0.0009% of the reference population or 0.008% of the South-east England MU; Table 12.46). The magnitude of the potential effect is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

543. The duration of concurrent piling, for two concurrent locations would be approximately half the total maximum duration for single pile installation, as well as reducing the overall construction window. The maximum concurrent piling duration (including ADD activation) for Norfolk Vanguard would be up to 699.5 hours (equivalent of up to approximately 29.5 days).

544. For the single phase approach this would be approximately 5% of the 20 month (608 days) foundation installation period. For the two phase approach this would be approximately 6% of each of the two eight month (243 day) foundation installation periods.

Table 12.46 Estimated number of harbour porpoise, grey seal and harbour seal potentially disturbed during concurrent piling based on 26km range

Potential Impact	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
Two concurrent piling events in NV West (3,520km^2)	Harbour porpoise	3,126 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,781 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.9% NS MU based on SCANS-III density. 0.8% of NS MU based on site specific survey density at NV West.	Temporary effect with **negligible** magnitude less than 1% of the reference population anticipated to be exposed to effect).
	Grey seal	7 grey seal based on offshore wind farm area density (0.002/km^2).	0.03% of ref pop (0.1% of SE England MU)	Temporary effect with **negligible** magnitude (less than 1% of reference population).
	Harbour seal	0.4 harbour seal based on offshore wind farm area density (0.0001/km^2).	0.0009% of ref pop (0.008% of SE England MU)	Temporary effect with **negligible** magnitude.
Two concurrent piling events in NV East (3,508km^2)	Harbour porpoise	3,115 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,420 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.9% of NS MU based on SCANS-III density. 1.3% of NS MU based on site specific survey density at NV East.	Temporary effect with **negligible** to **low** magnitude (between less than 1% and up to 5% of the reference population anticipated to be exposed to effect).
	Grey seal	7 grey seal based on offshore wind farm area density (0.002/km^2).	0.03% of ref pop (0.1% of SE England MU)	Temporary effect with **negligible** magnitude.
	Harbour seal	0.4 harbour seal based on offshore wind farm area density (0.0001/km^2).	0.0009% of ref pop (0.008% of SE England MU)	Temporary effect with **negligible** magnitude.
Two concurrent piling events based on one worst-case location in NV East	Harbour porpoise	3,772 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,354 harbour porpoise based	1% of NS MU based on SCANS-III density. 1.3% of NS MU based on site specific survey density at NV East & NV West.	Temporary effect with **low** magnitude (between 1% and 5% of the reference population anticipated to be exposed to effect).

Potential Impact	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
and one worst-case location NV West ($4,248km^2$)		on site specific survey density at NV East and NV West.		
	Grey seal	8.5 grey seal based on offshore wind farm area density ($0.002/km^2$).	0.04% of ref pop (0.1% of SE England MU)	Temporary effect with **negligible** magnitude.
	Harbour seal	0.4 harbour seal based on offshore wind farm area density ($0.0001/km^2$).	0.0009% of ref pop (0.008% of SE England MU)	Temporary effect with **negligible** magnitude.

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

Disturbance impact significance

545. Taking into account the receptor sensitivity and the potential magnitude of the temporary impact (e.g. number of individuals as a percentage of the reference population), the impact significance for any disturbance in harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant) (Table 12.47).

Table 12.47 Assessment of impact significance for disturbance of marine mammals as a result of underwater noise during piling

Potential Impact	Receptor	Sensitivity	Magnitude	Significance
Disturbance as a result of underwater noise during piling for single installation (2,124km^2)	Harbour porpoise	Medium	Negligible	**Minor adverse**
	Grey seal	Medium	Negligible	**Minor adverse**
	Harbour seal	Medium	Negligible	**Minor adverse**
Disturbance as a result of underwater noise during concurrent piling (4,248km^2)	Harbour porpoise	Medium	Negligible to Low	**Minor adverse**
	Grey seal	Medium	Negligible	**Minor adverse**
	Harbour seal	Medium	Negligible	**Minor adverse**

12.7.4.2.5 Possible behavioural response in harbour porpoise

Possible behavioural response sensitivity

546. The possible behavioural response severity scaling for multiple pulses is used as an indicator of ranges where behavioural changes and some level of reduction in animal abundance may be expected (possible avoidance) in cetaceans. While no data are reported in Southall *et al*. (2007) for high-frequency cetaceans (this category includes the harbour porpoise), in this assessment possible avoidance thresholds are considered to approximate to the severity scoring of 5-6 (Southall *et al*., 2007). This type of behavioural response has the ability to affect foraging, reproduction or survival, should an individual respond, but not all individuals that are exposed to this level or noise will respond.

547. The sensitivity of harbour porpoise to this type of effect is considered to be **low** (Table 12.36).

Possible behavioural response magnitude

548. The range of possible behavioural reactions that may occur as a result of exposure to noise include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour, temporary or permanent

habitat abandonment and, in severe cases, panic, or stranding, sometimes resulting in injury or death (Southall *et al*., 2007).

549. Based on the unweighted Lucke *et al*. (2009) criteria (unweighted SEL_{ss} of 145 dB re 1 $\mu Pa^2 s$), the estimated maximum range which could result in a possible behavioural response by harbour porpoise is estimated to be up to 84km and 68km for the maximum hammer energy of the monopile (5,000kJ) and pin-pile (2,7000kJ), respectively.

550. The response of individuals to a noise stimulus will vary and not all animals within the range of potential behavioural response will respond. The study of harbour porpoise at Horns Rev (Brandt *et al*., 2011), showed that at closer distances (2.5 to 4.8km) there was 100% avoidance, however, this proportion decreased significantly moving away from the pile driving activity, such that at distances of 10.1 to 17.8km, avoidance occurred in 32 to 49% of the population and at 21.2km, the abundance reduced by just 2%. This suggests that an assumption of behavioural displacement of all individuals is unrealistic and that in reality not all individuals would move out of the area. To take this into account, the proportion of harbour porpoise that may show a behavioural response has been calculated by assuming 50% could respond. This approach is consistent with the response at distances of 10.1 to 17.8km indicated by the Brandt *et al*. (2011) study, at which approximately 50% could respond at the maximum predicted level as suggested by the dose-response curve in Thompson *et al*. (2013) and the approach used in other offshore wind farm projects (for example, the Hornsea P3 PEIR (DONG Energy, 2017)).

551. It should be noted that a behavioural response does not mean that the individuals will avoid the area. In addition, the maximum predicted ranges for behavioural response are based on the maximum hammer energy, which would only be a small duration, if at all, of the piling activity and are based on the piling location with the maximum noise propagation, which vary considerably with location and will be less at the other piling locations.

552. The estimated number of harbour porpoise that could potentially exhibit a possible behavioural response as a result of a single strike of the maximum monopile hammer energy of 5,000kJ is up to 11,761 individuals (3% of the reference population) based on the Lucke *et al*. (2007) unweighted criteria, 50% of the harbour porpoise in the maximum predicted area responding and the site specific density for NV East (1.26 harbour porpoise per km^2) (Table 12.48). The magnitude of the potential effect is assessed as **low** with between 1% and 5% of the reference population anticipated to respond.

553. As outlined above, the maximum duration for the installation of a single pile is up to six hours, including the soft-start and ramp-up, however the average piling duration is expected to be three hours, plus an estimated ADD activation time of 10 minutes prior to the soft-start.

554. As outlined in section 12.7.4.2.4, it is important to note that piling and therefore any possible behavioural response would not be constant during the construction periods and phases of development. As outlined in section 12.7.4.2.4, if there are long gaps between construction phases, animals would be expected to return to the area after piling had ceased.

Table 12.48 Estimated number of harbour porpoise that could exhibit a possible behavioural response to underwater noise during piling based on unweighted Lucke *et al*. (2009) threshold of 145 dB re 1 µPa²s

Potential Impact	Estimated number based on 100% of individuals in area responding[1]	% of reference population[1]	Estimated number based on 75% of individuals in area responding[1]	% of reference population[1]	Estimated number based on 50% of individuals in area responding[1]	% of reference population[1]	Magnitude[2]
Possible behavioural response to underwater noise during piling – maximum hammer energy for monopile (18,668km²)	16,577 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 23,522 harbour porpoise based on site specific survey density (1.26/km²) at NV East. 14,748 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	5% of NS MU based on SCANS-III density. 7% of NS MU based on site specific survey density at NV East. 4% of NS MU based on site specific survey density at NV West.	12,433 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 17,642 harbour porpoise based on site specific survey density (1.26/km²) at NV East. 11,061 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	4% of NS MU based on SCANS-III density. 5% of NS MU based on site specific survey density at NV East. 3% of NS MU based on site specific survey density at NV West.	8,289 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 11,761 harbour porpoise based on site specific survey density (1.26/km²) at NV East. 7,374 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	2% of NS MU based on SCANS-III density. 3% of NS MU based on site specific survey density at NV East. 2% of NS MU based on site specific survey density at NV West.	Temporary effect with '**low**' magnitude (between 1% and 5% of the reference population anticipated to respond).
Possible behavioural response to underwater noise during piling – maximum hammer energy for pin-	11,247 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 15,959 harbour porpoise based on site specific survey density (1.26/km²)	3% of NS MU based on SCANS-III density. 5% of NS MU based on site specific survey density at NV East.	8,435 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 11,969 harbour porpoise based on site specific survey density (1.26/km²)	2% of NS MU based on SCANS-III density. 3.5% of NS MU based on site specific survey density at NV East.	5,624 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 7,980 harbour porpoise based on site specific survey density (1.26/km²)	2% of NS MU based on SCANS-III density. 2% of NS MU based on site specific survey density at NV East.	Temporary effect with '**low**' magnitude (between 1% and 5% of the reference population

Potential Impact	Estimated number based on 100% of individuals in area responding[1]	% of reference population[1]	Estimated number based on 75% of individuals in area responding[1]	% of reference population[1]	Estimated number based on 50% of individuals in area responding[1]	% of reference population[1]	Magnitude[2]
pile (12,666km²)	at NV East. 10,006 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	3% of NS MU (based on site specific survey density at NV West.	at NV East. 7,505 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	2% of NS MU based on site specific survey density at NV West.	at NV East. 5,003 harbour porpoise based on site specific survey density (0.79/km²) at NV West.	1.5% of NS MU based on site specific survey density at NV West.	anticipated to respond).

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

Possible behavioural response impact assessment

555. Taking into account the receptor sensitivity and the potential magnitude of the temporary impact (e.g. number of individuals as a percentage of the reference population), the impact significance for any possible behavioural response in harbour porpoise has been assessed as **minor adverse** (not significant) (Table 12.49).

556. In addition to the MMMP, a Norfolk Vanguard Southern North Sea cSAC Site Integrity Plan (SIP) will be developed and an in principle SIP (document 8.17) is provided with the DCO application. The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SNS cSAC.

Table 12.49 Assessment of impact significance for underwater noise during piling on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance
Possible behavioural response as a result of underwater noise during piling	Harbour porpoise	Low	Low	**Minor** adverse

12.7.4.2.6 Summary of underwater noise during piling impact significance assessment

557. The impact magnitudes described in sections 12.7.4.2.1 to 12.7.4.2.5 represent a conservative worst-case for the overall project by using the maximum density estimates and the maximum noise propagation (from pile locations in NV West). This conservative approach is deemed to be appropriate due to the mobile nature of marine mammals. Any configuration of installed infrastructure between NV East and NV West, up to the maximum capacity of 1800MW, will therefore be within the envelope of the impacts assessed.

558. Taking into account the receptor sensitivity and the potential magnitude of the impact (e.g. number of individuals as a percentage of the reference population), if the impact is permanent (e.g. PTS) or temporary (e.g. TTS and disturbance) and the proposed mitigation, the impact significance for any physical injury, permanent auditory injury, temporary auditory injury / fleeing response and disturbance in harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant) (Table 12.50).

559. The confidence in the data used in this assessment is medium and the level of precaution is high.

Table 12.50 Overall assessment of impact significance of underwater noise during piling on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance
Permanent auditory injury (PTS) injury as a result of underwater noise from single strike of starting hammer energy	Harbour porpoise	High	Negligible	**Minor adverse**
	Grey seal	High	Negligible	**Minor adverse**
	Harbour seal	High	Negligible	**Minor adverse**
Permanent auditory injury (PTS) injury as a result of underwater noise from single strike of maximum hammer energy	Harbour porpoise	High	Negligible based on use of embedded mitigation	**Minor adverse**
	Grey seal	High	Negligible with or without embedded mitigation	**Minor adverse**
	Harbour seal	High	Negligible with or without embedded mitigation	**Minor adverse**
Permanent auditory injury (PTS) injury as a result of underwater noise during piling from cumulative exposure	Harbour porpoise	High	Negligible with or without embedded mitigation	**Minor adverse**
	Grey seal	High	Negligible with or without embedded mitigation	**Minor adverse**
	Harbour seal	High	Negligible with or without embedded mitigation	**Minor adverse**
Temporary auditory injury (TTS) and fleeing response as a result of underwater noise from single strike of maximum hammer energy	Harbour porpoise	Medium	Negligible with or without embedded mitigation	**Minor adverse**
	Grey seal	Medium	Negligible with or without embedded mitigation	**Minor adverse**
	Harbour seal	Medium	Negligible with or without embedded mitigation	**Minor adverse**
Temporary auditory injury (TTS) and fleeing response as a result of underwater noise during piling from cumulative exposure	Harbour porpoise	Medium	Negligible with or without embedded mitigation	**Minor adverse**
	Grey seal	Medium	Negligible with or without embedded mitigation	**Minor adverse**
	Harbour seal	Medium	Negligible with or without embedded mitigation	**Minor adverse**
Disturbance as a result of underwater noise during piling for	Harbour porpoise	Medium	Negligible	**Minor adverse**
	Grey seal	Medium	Negligible	**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance
single installation (2,124km^2)	Harbour seal	Medium	Negligible	**Minor adverse**
Disturbance as a result of underwater noise during concurrent piling (4,248km^2)	Harbour porpoise	Medium	Negligible to Low	**Minor adverse**
	Grey seal	Medium	Negligible	**Minor adverse**
	Harbour seal	Medium	Negligible	**Minor adverse**
Possible behavioural response as a result of underwater noise during piling	Harbour porpoise	Low	Low	**Minor adverse**

12.7.4.3 Impact 3: Underwater noise during other construction activities

560. This section assesses the potential impacts that could be associated with underwater noise during construction activities other than pile driving (section 12.7.4.2) and noise associated with vessels (section 12.7.4.4). Potential source of underwater noise during other construction activities, include seabed preparation, rock dumping and cable installation.

561. The construction activity likely to have the greatest potential noise impacts, other than piling, is cable installation and has therefore been assessed as a worst-case scenario (Table 12.24).

562. The cable installation methods that are currently being considered are:

- Surface laid with cable protection where burial is not possible;
- Ploughing;
- Jetting;
- Dredging;
- Mass flow excavation;
- Trenching; and
- Rock dumping for protection of the cables.

563. There are no clear indications that underwater noise caused by the installation of sub-sea cables poses a high risk of harming marine fauna (OSPAR, 2009). However, behavioural responses of marine mammals to dredging, an activity emitting comparatively higher underwater noise levels, are predicted to be similar to those during cable installation (OSPAR, 2009).

564. Dredging produces continuous, broadband sound. Sound pressure levels (SPLs) can vary widely, for example, with dredger type, operational stage, or environmental conditions (e.g. sediment type, water depth, salinity and seasonal phenomena such as thermoclines; Jones and Marten, 2016). These factors will also affect the propagation of sound from dredging/cable installation activities and along with ambient sound already present, will influence the distance at which sounds can be detected.

565. Sound sources for trailing suction hopper dredger (TSHD) include the draghead on the seabed, material going through the underwater pipe, as well as sound sources from the vessel, such as inboard pump, thrusters, propeller and engine noise (CEDA, 2011, WODA, 2013). Noise measurements indicate that the most intense sound emissions from TSHD dredgers are typically low frequencies, up to and including 1kHz (Robinson *et al*., 2011). Underwater noise from a TSHD is comparable to those for a cargo ship travelling at modest speed (between 8 and 16 knots) (Theobald *et al*., 2011).

566. Based on reviews of published sources of underwater noise during dredging activity (e.g. Thomsen *et al*., 2006; CEDA, 2011; Theobald *et al*., 2011; WODA, 2013; Todd *et al*., 2014), sound levels that marine mammals may be exposed to during dredging activities are usually below auditory injury thresholds or PTS exposure criteria; however, TTS cannot be ruled out if marine mammals are exposed to noise for prolonged periods (Todd *et al*., 2014), although marine mammals remaining in close proximity to such activities for long periods of time is unlikely. Therefore, the potential risk of any auditory injury (permanent or temporary) in marine mammals as a result of dredging / cable installation activity is highly unlikely.

567. Underwater noise as a result of dredging activity, and therefore cable installation, also has the potential to disturb marine mammals (Pirotta *et al*., 2013). Therefore, there is the potential for short, perhaps medium-term behavioural reactions and disturbance to marine mammals in the area during dredging / cable installation activity. Marine mammals may exhibit varying behavioural reactions intensities as a result of exposure to noise (Southall *et al*., 2007).

568. The noise levels produced by dredging activity, and therefore cable installation, could overlap with the hearing sensitives and communication frequencies used by marine mammals (Todd *et al*., 2014), and therefore have the potential to impact marine mammals present in the area. However, species such as harbour porpoise, have a relatively poor sensitivity below 1kHz are less likely to be affected by masking, although for seals there could be the potential of masking communication, especially during the breeding season (Todd *et al*., 2014).

12.7.4.3.1 Sensitivity

569. The sensitivity of marine mammals to disturbance as a result of underwater noise during construction activities, such as cable installation, is considered to be **medium** in this assessment as a precautionary approach. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects (see Table 12.5), although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

12.7.4.3.2 Magnitude

570. The potential for TTS is only likely in very close proximity to cable laying or rock dumping activities, and noise generated should not be sufficient to cause PTS or other injury to marine mammals (Todd *et al*., 2014). Disturbance is therefore the only potential noise effect associated with these construction activities.

571. As a precautionary worse-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be disturbed as a result of underwater noise during construction from activities other than piling and vessel movements has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 12.51) and 100% disturbance of all individuals in these areas. This is very precautionary, as it is highly unlikely that construction activities, other than piling activity, could result in disturbance from the entire wind farm area and the offshore cable corridor. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

Table 12.51 Estimated number of harbour porpoise, grey seal and harbour seal that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor)

Potential Impact Area	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
NV East area ($297km^2$)	Harbour porpoise	264 harbour porpoise based on SCANS-III survey block O density ($0.888/km^2$). 374 harbour porpoise based on site specific survey density ($1.26/km^2$) at NV East.	0.08% of NS MU based on SCANS-III density. 0.1% of NS MU based on site specific survey density at NV East.	Temporary effect with **negligible** magnitude (less than 1% of the reference population anticipated to be exposed to effect).
	Grey seal	0.6 grey seal based on offshore wind farm area density ($0.002/km^2$).	0.003% of ref pop (0.01% of SE England MU).	Temporary effect with **negligible** magnitude.
	Harbour seal	0.03 harbour seal based on offshore wind farm area density	0.00007% of ref pop (0.0006% of SE England	Temporary effect with **negligible**

Potential Impact Area	Receptor	Estimated number in impact area[1]	% of reference population[1]	Magnitude[2]
		(0.0001/km^2).	MU).	magnitude.
NV West area (295km^2)	Harbour porpoise	262 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 233 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.08% of NS MU based on SCANS-III density. 0.07% of NS MU based on site specific survey density at NV West.	Temporary effect with **negligible** magnitude.
	Grey seal	0.6 grey seal based on offshore wind farm area density (0.002/km^2).	0.003% of ref pop (0.01% of SE England MU).	Temporary effect with **negligible** magnitude.
	Harbour seal	0.03 harbour seal based on offshore wind farm area density (0.0001/km^2).	0.00007% of ref pop (0.0006% of SE England MU).	Temporary effect with **negligible** magnitude.
Offshore cable corridor (237km^2)	Harbour porpoise	210.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 299 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.06% of NS MU based on SCANS-III density. 0.09% of NS MU based on site specific survey density at NV East.	Temporary effect with **negligible** magnitude.
	Grey seal	38 grey seal based on offshore cable corridor area density (0.16/km^2).	0.2% of ref pop (0.6% of SE England MU).	Temporary effect with **negligible** magnitude.
	Harbour seal	24 harbour seal based on offshore cable corridor area density (0.1/km^2).	0.06% of ref pop (0.5% of SE England MU).	Temporary effect with **negligible** magnitude.
Total offshore project area (829km^2)	Harbour porpoise	736.5 harbour porpoise based on SCANS-III survey block O density. 906 harbour porpoise based on site specific survey densities for NV East and NV West.	0.2% of NS MU based on SCANS-III density. 0.3% of NS MU based on site specific survey density.	Temporary effect with **negligible**.
	Grey seal	39 grey seal based on number on OWF sites and offshore cable corridor.	0.2% of ref pop (0.6% of SE England MU).	Temporary effect with **negligible** magnitude.
	Harbour seal	24 harbour seal based on number on OWF and offshore cable corridor.	0.06% of ref pop (0.5% of SE England MU).	Temporary effect with **negligible** magnitude.

[1]Based on density estimate and reference population (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

572. The magnitude of effect in all species is **negligible**, with less than 1% of the reference population being likely to be temporarily affected. As outlined in Table 12.51, it is estimated that approximately 906 harbour porpoise could be present in the wind farm sites and offshore cable corridor area (based on site specific survey densities for NV East and NV West), which represents 0.3% of the North Sea MU reference population. There is an estimated 39 grey seal and 24 harbour seal that could be present in the wind farm sites and offshore cable corridor area (based on seal-at sea density maps; Russell *et al*., 2017), which represents 0.2% of the grey seal reference population (0.6% of the grey seal South-east England MU) and 0.06% of the harbour seal reference population (0.5% of the South-east England MU) (Table 12.51).

573. Based on a more realistic, but precautionary approach that up to 50% of all individuals could potentially be disturbed from the wind farm sites and offshore cable corridor area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population), 19.5 grey seal (0.09% of reference population; 0.3% of the grey seal South-east England MU) and up to 12 harbour seal (0.03% of reference population; 0.2% of the harbour seal South-east MU) could be temporarily displaced.

574. The indicative duration of the cable installation, is estimated to be:

- 19 months for single phase option; or
- 7 months per phase for two phase option.

575. The indicative duration of the overall construction activity is estimated to be:

- 20 months for single phase option; or
- 12 months per phase for two phase option.

576. The indicative total programme for construction of the full 1800MW capacity is estimated to be four years depending on the time between commencements of the phases.

577. The potential effects that could result from underwater noise during other construction activities, including cable laying and protection would be temporary in nature, not consistent throughout these periods and would be limited to only part of the overall construction period and area. The number of harbour porpoise, grey seal and harbour seal presented in Table 12.51 are the maximum number of animals that could be present in the area and potentially disturbed at the commencement and for the duration of any construction activities, other than piling.

12.7.4.3.3 Impact significance

578. Taking into account the receptor sensitivity and the potential magnitude of the effect and the temporary nature of the disturbance, the impact significance for any disturbance as a result of underwater noise from other construction activities (e.g. cable installation) on harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant) (Table 12.52); therefore no further mitigation measures are proposed beyond those embedded measures presented in section 12.7.1.

579. It should be noted that construction activities, other than piling, underway at the same time as piling, are not cumulative impacts, as the maximum potential impact area for construction activities, other than piling, are less than those assessed for piling and will therefore be included in the predicted disturbance impact area assessed for piling.

580. The confidence in the data used in this assessment is medium and the level of precaution is high.

Table 12.52 Assessment of impact significance for underwater noise from other construction activities (e.g. cable installation) on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Disturbance from other construction activities (e.g. cable installation)	Harbour porpoise	Medium	Negligible	Minor	No mitigation required	**Minor adverse**
	Grey seal	Medium	Negligible	Minor		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor		**Minor adverse**

12.7.4.4 Impact 4: Vessel underwater noise and disturbance

581. During the construction phase there will be an increase in the number of vessels associated with installation of the turbine foundations and associated sub-structures and also with the installation of the inter-array and export cables. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore any increase in disturbance as a result of underwater noise from vessels during construction will be within the wind farm site and offshore cable corridor.

582. It is anticipated that the types of vessels that could be on site during construction include:

- Seabed preparation vessels

- Transition piece installation vessels
- Scour Installation Vessels
- WTG installation vessels
- Commissioning vessels
- Accommodation vessels
- Inter-array cable laying vessels
- Export cable laying vessels
- Landfall cable installation vessels
- Substation / collector station installation vessels
- Other vessels

583. The maximum number of vessels on site at any one time during construction is estimated to be 57 vessels.

584. The vessels within the site will be slow moving (or stationary) and most noise emitted is likely to be of a lower frequency. Noise levels reported by Malme *et al*. (1989) and Richardson *et al*. (1995) for large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. However, the levels could be sufficient to cause local disturbance to sensitive marine mammals in the immediate vicinity of the vessel, depending on ambient noise levels.

585. Underwater noise generated by vessels would not be sufficient to cause PTS or other injury to marine mammals. The potential for TTS is only likely if the animal remains in very close proximity to a vessel for a prolonged period of time, which is highly unlikely. Disturbance is therefore the only potential underwater noise effect associated with vessels.

586. Modelling by Heinänen and Skov (2015) indicates that the number of ships represents a relatively important factor determining the density of harbour porpoise in the North Sea MU during both seasons, with markedly lower densities with increasing levels of traffic. A threshold level in terms of impact seems to be approximately 20,000 ships per year (approximately 80 vessels per day within a $5km^2$ area).

587. Chapter 15 Shipping and Navigation provides a description of the baseline conditions and anticipated additional ship movements arising from the construction and operation of the proposed project.

588. A number of busy shipping lanes pass in proximity to the Norfolk Vanguard site, with a large number of vessels recorded using two Deep Water Routes (DWRs), one passing approximately 1nm (1.85km) from both the NV East and NV West sites and the other passes approximately 2nm (3.7km) to the east of NV East (Chapter 15 Shipping and Navigation).

589. Baseline surveys for shipping and navigation indicate that throughout the summer period of the marine traffic survey, there was on average 69, 46 and 96 unique vessels per day recorded within NV East, NV West and offshore cable corridor, respectively. Throughout the winter period of the marine traffic survey, there was on average 63, 39 and 92 unique vessels per day recorded within the NV East, NV West and offshore cable corridor, respectively. The majority of vessels recorded were cargo vessels and tankers, with most of these vessels utilising the IMO Routeing Measures in the area; however other main routes were identified out with the DWRs, including routes which intersected the OWF sites. Fishing activity was also notable in the area (Chapter 15 Shipping and Navigation). Indicating an already relatively high shipping activity in and around Norfolk Vanguard.

590. There would be some re-routing of existing vessels around the Norfolk Vanguard site, with a minimum passing distance of 500m from areas where construction is underway. This is likely to re-route existing large and fast moving vessels (predominantly general cargo ships).

591. During the construction there will be an increase in vessels within the site associated with installation of the foundations, the wind turbines, inter-array and export cables, despite the potential displacement of existing vessel traffic. Table 12.24 provides details of the worst-case scenario for vessels during construction.

592. The maximum number of vessels on site at any one time during construction is estimated to be 57 vessels. This could therefore represent up to a 27% increase in the number of vessels during the summer period and 29% increase in the number of vessels during the winter periods, compared to current baseline vessel numbers.

593. The maximum number of 57 vessels at any one time in the offshore project area ($829km^2$) during construction would be significantly less than the Heinänen and Skov (2015) threshold of 80 vessels per day within an area of $5km^2$. Based on the precautionary worst-case scenario, including existing vessel movements in around the Norfolk Vanguard area, but taking into account that other vessels would be restricted from entering the immediate construction site (with a 500m safety zone around construction vessels and partially installed foundations), the number of vessels would be unlikely to exceed the Heinänen and Skov (2015) threshold level of 80 vessels per day in a $5km^2$ area. Therefore, there is unlikely to be the potential for significant disturbance to harbour porpoise as a result of the increased number of vessels during construction.

12.7.4.4.1 Sensitivity

594. Thomsen *et al*. (2006) reviewed the effects of ship noise on harbour porpoise and seal species. As both species use lower frequency sound for communicating (with

acute hearing capabilities at 2kHz) there is the potential for detection, avoidance and masking in both species. Thomsen *et al*. (2006) considered the detection thresholds for harbour porpoises (Hearing threshold = 115dB rms re 1 µPa at 0.25 kHz; Ambient noise = 91dB rms re 1 µPa at 2kHz) and conclude that ship noise around 0.25kHz could be detected by the species at distances of 1km; and ship noise around 2kHz could be detected at around 3km[5].

595. Given this range of predicted response, and observations of harbour porpoise swimming away from vessels (e.g. Polacheck and Thorpe 1990; Evans *et al*., 1993), harbour porpoise are considered to have **low** sensitivity to vessel noise.

596. Thomsen *et al*. (2006) also consider that ship noise around 2kHz will be detected at a distance of approximately 3km for harbour seals (ambient noise = 94 and 91dB rms re 1µPa at 0.25 and 2 kHz, respectively); and the zone of audibility will be approximately 20km. However, there is no evidence to suggest that vessel noise adversely affects seals, suggesting they may have a lower sensitivity than cetacean species. As such, both harbour and grey seal are considered to have a **low** sensitivity to vessel noise.

12.7.4.4.2 Magnitude

597. The potential for TTS / fleeing response is only likely if the animal remains in very close proximity to a vessel for a prolonged period of time. Underwater noise generated by vessels would not be sufficient to cause PTS or other injury to marine mammals. Disturbance is therefore the only potential underwater noise impact associated with vessels.

598. As a precautionary worse-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be disturbed as a result of underwater noise from vessels has been assessed based on the number of animals that could be present in the offshore wind farm areas and the offshore cable corridor (Table 12.51). This is very precautionary, as it is highly unlikely that underwater noise from vessels could result in disturbance from the entire offshore wind farm areas and the offshore cable corridor at any one time. Any disturbance is likely to be limited to the immediate vicinity around the actual vessel.

599. Underwater noise and disturbance from additional vessels during construction are likely to be localised in comparison to existing shipping noise. The disturbance of marine mammals from the presence and underwater noise of vessels would be

[5] These calculations are valid for ambient noise levels typical for the German Bight / North Sea at wind-speeds between 3 and 8m/s.

temporary as the vessels move in and out of the site and move between different locations within the site, marine mammals would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

600. It has been assumed that vessels could be present on the site for the duration of the construction period (e.g. the worst-case is estimated to be up to four years). Therefore, the potential disturbance from vessels during construction would be temporary (e.g. less than five years) and intermittent.

601. It is estimated that approximately 906 harbour porpoise (0.3% of the North Sea MU reference population) could be present in the wind farm sites and offshore cable corridor area (based on the highest density estimate; Table 12.51). There is an estimated 39 grey seal and 24 harbour seal that could be present in the wind farm sites and offshore cable corridor area, which represents 0.2% of the grey seal reference population (0.6% of the South-east England MU) and 0.06% of the reference population for harbour seal (0.5% of the South-east England MU) (Table 12.51). The magnitude of effect in all species is **negligible**, with less than 1% of the reference population being likely to be temporarily affected.

602. Based on a more realistic, but precautionary approach that up to 50% of all individuals could potentially be disturbed from the wind farm sites and offshore cable corridor area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population), 19.5 grey seal (0.09% of reference population; 0.3% of the grey seal South-east England MU) and up to 12 harbour seal (0.03% of reference population; 0.2% of the harbour seal South-east MU) could be temporarily displaced. The magnitude of effect in all species is **negligible**, with less than 1% of the reference population being likely to be temporarily affected.

12.7.4.4.3 Impact significance

603. Taking into account the receptor sensitivity and the potential magnitude of the impact and the temporary and intermittent nature of the disturbance, the impact significance for any disturbance as a result of underwater noise from vessels for harbour porpoise, grey seal and harbour seal has been assessed as **negligible,** with less than 1% of the reference populations likely to be temporarily affected (Table 12.53); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1. It should be noted that disturbance from vessels will not be cumulative with piling or any other construction activity impacts as any impact areas will be overlapped by the piling impact areas.

604. The confidence in the data used in this assessment is medium to high.

Table 12.53 Assessment of impact significance for underwater noise and disturbance from vessels on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Disturbance from vessel noise during construction for total offshore project area	Harbour porpoise	Low	Negligible	Negligible	No mitigation required or proposed.	**Negligible**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.7.4.5 Impact 5: Barrier effects from underwater noise

12.7.4.5.1 Sensitivity

605. Harbour porpoise, grey seal and harbour seal are assessed as having **medium** sensitivity to a barrier effect as a result of disturbance (Table 12.39).

12.7.4.5.2 Magnitude

606. Underwater noise during construction could have the potential to create a barrier effect, preventing movement or migration of marine mammals between important feeding and / or breeding areas, or potentially increasing swimming distances if marine mammals avoid the site and go around it. However, the Norfolk Vanguard offshore project area is not located on any known migration routes for marine mammals. Telemetry studies (sections 12.6.2.1 and 12.6.2.2.1) and the relatively low seal at sea usage observed (Russell *et al.* 2017; Figure 12.2 and 12.3) in and around the Norfolk Vanguard offshore project area (section 12.6.2) do not indicate any regular seal foraging routes through the site.

607. The worst-case scenario in relation to barrier effects as a result of underwater noise is based on the maximum spatial and temporal (i.e. longest duration) scenarios.

Maximum spatial impact for any barrier effects

608. The spatial worst-case is the maximum area (4,248km^2) over which potential disturbance could occur at any one time based on two concurrent foundations being installed (Table 12.46). However, this would only be for a relatively small duration of the potential construction period.

609. As outlined in section 12.7.4.2.4, the estimated maximum number of harbour porpoise that could potentially be temporarily disturbed as a result of underwater noise from concurrent piling is 1.3% of the reference population (Table 12.46), based on the worst-case scenario. The magnitude of the potential impact is assessed as **low**, with between 1% and 5% of the reference population anticipated to be exposed to the temporary effect.

610. As outlined in section 12.7.4.2.4, the estimated maximum number of grey seal that could potentially be disturbed as a result of underwater noise from concurrent piling is 0.04% of the reference population (0.1% of the South-east England MU). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect (Table 12.46).

611. As outlined in section 12.7.4.2.4, the estimated maximum number of harbour seal that could potentially be disturbed as a result of underwater noise from concurrent piling is 0.0009% of the reference population (0.008% of the South-east England MU). The magnitude of the potential impact is assessed as **negligible**, with less than 1% of the reference population anticipated to be exposed to the temporary effect.

Maximum temporal impact for any barrier effects

612. The duration of concurrent piling, for two concurrent locations would be approximately half the total maximum duration for single pile installation, as well as reducing the overall construction window. The maximum concurrent piling duration (including ADD activation) for Norfolk Vanguard would be up to 699.5 hours (equivalent of up to approximately 29.5 days).

613. For the single phase approach this would be approximately 5% of the 20 month (608 days) foundation installation period and 4% of the 23 month (700 day) overall construction period.

614. For the two phase approach this would be approximately 15 days per phase and therefore 6% of each of the two eight month (243 day) foundation installation periods and 4% of the two 12 month (365 day) overall construction periods.

615. As outlined above, it is important to note that piling and therefore any potential barrier effects would not be constant during the construction periods and phases of development. It is therefore important to take into account that when piling is not taking place, there are periods where marine mammals could return to the area, rather than assuming that they will be disturbed / move away for the entire construction period.

616. The magnitude for any potential barrier as a result of underwater noise has been based on the maximum potential disturbance area and on the basis that any associated barrier effects would be temporary and intermittent.

12.7.4.5.3 Impact significance

617. As outlined above, piling activity would only be for a very small proportion of the construction period, therefore any potential barrier effects from piling activity would

not be long-term and would only be temporary. Underwater noise from other activities and vessels (section 12.7.4.3 and section 12.7.4.4) would have a limited area of potential disturbance and negligible magnitude of effect, and would therefore not result in any potential barrier effects.

618. Therefore, taking into account the receptor sensitivity and the potential magnitude of the temporary impact, the impact significance for any potential barrier as a result of underwater noise during construction has been assessed as **minor adverse** (not significant) for harbour porpoise, grey seal and harbour seal (Table 12.54).

619. The confidence in the data used in this assessment is medium with a precautionary approach, based on maximum potential piling durations for each pile.

Table 12.54 Assessment of impact significance for any barrier effects from underwater

Potential Impact	Receptor	Sensitivity	Magnitude for temporary effect	Significance for temporary effect	Mitigation	Residual impact
Potential barrier effects from underwater noise during construction	Harbour porpoise	Medium	Low	Minor adverse	MMMP to reduce impacts from piling noise	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**

12.7.4.6 Impact 6: Vessel collision risk

12.7.4.6.1 Sensitivity

620. Marine mammals in the Norfolk Vanguard area would be habituated to the presence of vessels and would be able to detect and avoid vessels. Therefore, harbour porpoise, grey seal and harbour seal are considered to have a **low** sensitivity to the risk of a vessel strike.

12.7.4.6.2 Magnitude

621. During the construction of Norfolk Vanguard there will be an increase in vessel traffic. Vessels will follow established shipping routes utilising the shipping lane between NV East and NV West and routes to the relevant ports in order to minimise vessel traffic in the wider area.

622. For Norfolk Vanguard West and Norfolk Vanguard East, alone or for the two sites combined, the overall worst-case scenarios for vessel movements during construction would be:

- Up to 1,180 two-way vessel movements based on a Single Phase approach; or
- Up to 1,180 (590 x2) two-way vessel movements for a Two Phased approach.

623. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the south east coast of England. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Vanguard are estimated to be an average of two per day. The maximum number of vessels on site at any one time would be 57.

624. As outlined in section 12.7.4.4, Chapter 15 Shipping and Navigation provides a description of the baseline conditions and anticipated additional ship movements arising from the construction and operation of the proposed project. The baseline conditions indicate an already relatively high level of shipping activity in and around Norfolk Vanguard.

625. Therefore, based on the worst-case scenario of an average of two vessel movements per day, the increase in vessels movement per day at the Norfolk Vanguard site during construction is going to be relatively small compared to existing vessel traffic. Although there could be a maximum of 57 vessels on site at any one time, most vessels once on site would remain within the site area.

626. The additional vessel movements associated with the construction of Norfolk Vanguard could have the potential to increase the collision risk with marine mammals.

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

628. Marine mammals are relatively robust with a thick sub-dermal layer of blubber that provides some protection for their vital organs in the event of a vessel strike (Wilson *et al*., 2007). However, non-fatal collisions can leave the animal vulnerable to secondary infection, other complications or predation (Wilson *et al*., 2007).

629. Studies have shown that larger vessels are more likely to cause the most severe or lethal injuries, with vessels over 80m in length causing the most damage to marine mammals (Laist *et al*., 2001). Vessels travelling at high speeds are considered to be more likely to collide with marine mammals, and those travelling at speeds below 10 knots would rarely cause any serious injury (Laist *et al*., 2001). It is not possible to

fully quantify strike rates between marine mammals and vessels because it is believed that a number go unnoticed (Evans *et al*., 2011).

630. Harbour porpoises are small and highly mobile, and given their responses to vessel noise (e.g. Thomsen *et al*., 2006; Evans *et al*., 1993; Polacheck and Thorpe, 1990), are expected to largely avoid vessel collisions. Heinänen and Skov (2015) indicated a negative relationship between the number of ships and the distribution of harbour porpoises in the North Sea suggesting potential avoidance behaviour. However, harbour porpoises have been observed with signs of physical trauma (blunt trauma or propeller cuts) indicating vessel strike.

631. Of the 273 reported harbour porpoise strandings in 2015 (latest UK Cetacean Strandings Investigation Programme Report currently available), 53 were investigated at post mortem (27 were conducted in England, 13 in Scotland and 13 in Wales). A cause of death was established in 51 examined individuals (approximately 96% of examined cases). Of these, four (8%) had died from physical trauma of unknown cause, which could have been vessel strikes (CSIP, 2015). Approximately 4% of all harbour porpoise post mortem examinations from the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS area) are thought to have evidence of interaction with vessels (Evans *et al*., 2011). Therefore, although the risk of collision is likely to be low, a precautionary 90-95% avoidance rate has been used in the assessment.

632. Ship strikes involving species of seal are not widely reported (with the exception of potential impacts related to ducted propellers discussed below). Typically, therefore, it is expected that grey seal and harbour seal in the area would be able to detect the presence of vessels and, given that they are highly mobile, would be able to largely avoid vessel collision.

633. In recent years there has been concern and research into the potential risks of 'corkscrew' type injuries to seals associated with ducted propellers (Thompson *et al*., 2010a, 2013a; Bexton *et al*., 2013). There is now incontrovertible evidence that such injuries can be caused by grey seal predation (Thompson *et al*., 2015), however research by SMRU showed that similar injury patterns could be caused by ducted propellers (Thompson *et al*., 2010a; SMRU, 2014). Therefore, the advice from the SNCBs (i.e. Scottish Natural Heritage, Natural England, Natural Resources Wales, Joint Nature Conservation Committee) in February 2015, was that it is considered very unlikely that the use of vessels with ducted propellers pose any increased risk to seals over and above normal shipping activities and, therefore, mitigation measures and monitoring may not be necessary in this regard, although all possible care should be taken in the vicinity of major seal breeding and haul-out sites to avoid collisions (SNCBs, 2015).

634. As a precautionary worse-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be at increased collision with vessels during construction has been assessed based on the number of animals that could be present in the wind farm areas and the offshore cable corridor and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 12.55).

635. This is very precautionary, as it is highly unlikely that all marine mammals present in the Norfolk Vanguard area would be at increased collision risk with vessels during construction, especially taking into account the increase in number of vessel movements compared to existing vessel movements in the area.

636. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where marine mammals are accustomed to vessels, in order to reduce any increased collision risk. All vessel movements will be kept to the minimum number that is required to reduce any potential collision risk. Additionally, vessel operators will use good practice to reduce any risk of collisions with marine mammals.

637. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed from the Norfolk Vanguard offshore wind farm site and cable corridor as a result of underwater noise from construction activities and vessels, there should be no potential for increased collision risk with vessels at Norfolk Vanguard during the construction period.

Table 12.55 Estimated number of harbour porpoise, grey seal and harbour seal that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor) at potential increased collision risk based on 95-90% avoidance

Potential Impact Area	Receptor	Estimated number at potential increased collision risk based on 95-90% avoidance	% of reference population[1]	Magnitude[2] for permanent impact
Total offshore project area (829km^2)	Harbour porpoise	37-74 harbour porpoise based on SCANS-III survey block O density. 45-91 harbour porpoise based on site specific survey densities for NV East and NV West.	0.01-0.02% of NS MU based on SCANS-III density. 0.01-0.03% of NS MU based on site specific survey density.	Permanent effect with **medium** magnitude (between 0.01% and 1% of the reference population anticipated to be exposed to effect
	Grey seal	2-4 grey seal based on number on OWF and offshore cable corridor.	0.009-0.02% of ref pop (0.03-0.07% of SE England MU).	Permanent impact with **low** magnitude (between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).
	Harbour seal	1-2 harbour seal based on number on OWF and offshore cable corridor.	0.002-0.005%of ref pop (0.02-0.04% of SE England MU).	Permanent impact with **low** magnitude (between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).

[1]Based on density estimates and reference populations (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

12.7.4.6.3 Impact significance

638. Taking into account the receptor sensitivity and the potential magnitude of the impact, the impact significance for any potential increase in collision risk with vessels during construction has been assessed as **minor adverse** (not significant) for harbour porpoise, grey seal and harbour seal (Table 12.56). No further mitigation measures are proposed beyond those embedded measures presented in section 12.7.1.

639. The confidence in the data used in this assessment is medium.

Table 12.56 Assessment of impact significance for increased collision risk from vessels during operation

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Increased collision risk from vessels during construction for total offshore project area	Harbour porpoise	Low	Medium	Minor	No further mitigation proposed other than good practice.	**Minor adverse**
	Grey seal	Low	Low	Minor		**Minor adverse**
	Harbour seal	Low	Low	Minor		**Minor adverse**

12.7.4.7 Impact 7: Disturbance at seal haul-out sites

12.7.4.7.1 Sensitivity

640. Taking into account the proximity of shipping channels to and from existing ports, it is likely that seals hauled-out along these routes and in the area of the ports would be habituated to the noise, movements and presence of vessels. Therefore, the sensitivity of grey and harbour seals at haul-out sites to disturbance from vessels during construction is likely to be **negligible**. However, as a very precautionary approach, it is proposed that sensitivity during the breeding season and annual moult could be slightly higher and has therefore been considered as **low** in this assessment. Although at Donna Nook in Lincolnshire, it seems that seals have become habituated to human disturbance and over 70,000 people visit this colony during the breeding season with no apparent impact on the breeding seals (SCOS, 2017). The grey seal annual moult is between December and April and their breeding season is between early November and mid-December (see section 12.6.2.1.2). Harbour seal give birth to their pups in June and July and moult in August (see section 12.6.2.2.2).

12.7.4.7.2 Magnitude

641. The response of seals to disturbance at haul-out sites can range from increased alertness to moving into the water (Wilson, 2014). The potential impact on pupping groups can include temporary or permanent pup separation, disruption of suckling, energetic costs and energetic deficit to pups, physiological stress and sometimes enforced move to distant or suboptimal habitat. Potential impacts on moulting groups can include energy loss and stress, while impacts on other haul-out groups can cause loss of resting and digestion time and stress (Wilson, 2014). The potential impacts will be determined by the response of the seals, the duration and proximity of the disturbance to the seals.

642. Studies on the distance of disturbance, on land or in the water, from hauled-out harbour seals have found that the closer the disturbance, the more likely seals are to move into the water. The estimated distance between a disturbance and haul out site, at which most seal movements into the water occur, varies for different locations and type of disturbance, but has been estimated at typically less than 100m (Wilson, 2014). For the grey seal, mothers responded by moving into the water more due to boat speed than as a result of the distance, although movement into the water was generally observed to occur at distances of between 20 and 70m, with no detectable disturbance at 150m (Wilson, 2014; Strong and Morris, 2010). However, grey and harbour seals have also been reported to move into the water when vessels are at a distance of approximately 200m to 300m (Wilson, 2014).

643. The Norfolk Vanguard offshore wind farm sites are located approximately 47km offshore (at the closest point of NV West). Principal grey seal and harbour seal haul-out sites are at:

- Horsey, located 48km from the offshore wind farm sites;
- Scroby Sands, approximately 47km from the offshore wind farm sites;
- Blakeney Point, approximately 88km from the offshore wind farm sites;
- Donna Nook, approximately 149km from the offshore wind farm sites; and
- The Wash, approximately 79km from the offshore wind farm sites.

644. The main breeding site for harbour seal on the east coast of England is in The Wash (SCOS, 2017). The main breeding site for grey seal on the east coast of England is at Blakeney Point (SCOS, 2017).

645. There is therefore no potential for any direct disturbance as a result of construction activities within the offshore wind farm site due to the distances between the Norfolk Vanguard offshore wind farm site and the nearest seal haul-out sites.

646. The landfall at Happisburgh South, which is approximately:

- 11km from the Horsey seal haul-out site to the south; and
- 43km from the Blakeney Point haul-out site to the north.

647. Given the distances between the Norfolk Vanguard cable landfall area and the nearest known seal haul-out sites; there is no potential for any direct disturbance as a result of construction activities within the cable corridor and landfall site.

648. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the south east coast of England. Vessel movements to and from any port, where possible, will be incorporated within existing vessel routes. Vessel movements either to the windfarm or cable route would use direct routes and are unlikely to be close to the shore (i.e. within a few hundred metres) except when near the port to avoid the risk of collision and grounding. However, taking into account the proximity of shipping channels to and from existing ports, it is likely that any seals hauled-out along these routes and in the area of the ports would be habituated to the noise, movements and presence of vessels. There is therefore no potential for any direct disturbance at seal haul-out sites as a result of vessels moving to and from the windfarm sites and cable corridor, as vessels would not be moving at distances of 500m or less off the coast.

649. The potential for any increase in disturbance to seal haul-out sites as a result of construction activities at the offshore wind farm sites, activities along the cable route and at landfall site, or from vessels movements during construction will be **negligible**.

12.7.4.7.3 Impact significance

650. Taking into account the receptor sensitivity and the potential magnitude of the impact and the temporary nature of the disturbance, the impact significance for any disturbance at seal haul-out sites during construction has been assessed as **negligible** (not significant) (Table 12.57); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1.

651. The confidence in the data used in this assessment is medium to high.

Table 12.57 Assessment of impact significance for disturbance at seal haul-out sites during construction

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Disturbance at seal haul-out sites during construction	Grey seal	Low	Negligible	Negligible	No mitigation required or proposed	**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.7.4.8 Impact 8: Changes to prey resource

12.7.4.8.1 Sensitivity

652. Grey and harbour seal feed on a variety of prey species, both are considered to be opportunistic feeders, they are able to forage in other areas and have relatively large foraging ranges (see section 12.6.2). Grey seal and harbour seal are therefore considered to have **low** sensitivity to changes in prey resources.

653. The diet of the harbour porpoise consists of a wide variety of prey species and varies geographically and seasonally, reflecting changes in available food resources. As outlined in section 12.6.1.1, harbour porpoise have relatively high daily energy demands and need to capture enough prey to meet its daily energy requirements. It has been estimated that, depending on the conditions, harbour porpoise can rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al*., 1997). Harbour porpoise are therefore considered to have **low** to **medium** sensitivity to changes in prey resources.

12.7.4.8.2 Magnitude

654. Potential impacts on marine mammal prey species have been assessed in Chapter 11 Fish and Shellfish Ecology using the appropriate realistic worst-case scenarios for these receptors. The existing environment for the assessment has been informed by site specific surveys and a number of existing data sources.

655. Potential impacts on fish species during construction can result from physical disturbance and temporary loss of seabed habitat; increased suspended sediment concentrations and sediment re-deposition; and underwater noise (that could lead to mortality, physical injury, auditory injury or behavioural responses). None of the potential impacts are assessed as being significant (**minor adverse** at worst; Chapter 11 Fish and Shellfish Ecology).

656. As outlined in Chapter 11 Fish and Shellfish Ecology, the maximum (worst-case scenario) potential area of physical disturbance and/or temporary loss of habitat to fish during construction could be 15.7km^2 in total for the OWF sites (this would account for a very small proportion (2.7%) of the area of the OWF sites) and 13km^2 for the offshore cable corridor. The assessment determined that with the low magnitude of impact, the impact on fish species, including sandeel and herring, would be of **minor adverse** significance (not significant; Chapter 11 Fish and Shellfish Ecology).

657. Similarly, the magnitude of impact on prey from any increased suspended sediment concentrations and sediment re-deposition would be low, with only a small proportion of fine sand and mud staying in suspension long enough to form a passive

plume. As outlined in section 12.7.4.9, this plume (tens of mg/l) would only exist for half a tidal cycle (i.e. approximately 6 hours), the sediment would then settle to the seabed within approximately 1km along the axis of tidal flow from the location at which it was released and these deposits would be very thin (millimetres). For the offshore cable installation, it is predicted that in water depths greater than 20m LAT (which are seen across the majority of the offshore cable corridor), peak suspended sediment concentrations would be typically less than 100mg/l, except in the immediate vicinity (a few tens of metres) of the release location. In shallow water nearer to shore (less than 5m LAT), the potential for dispersion is more limited and therefore the concentrations are likely to be greater, approaching 400mg/l at their peak. However, these plumes would be localised to within less than 1km of the location of installation and would persist for no longer than a few hours. Following cessation of installation activities any plume would have been fully dispersed as a result of advection and diffusion. Therefore, the assessment determined that with the low magnitude of impact, the impact on fish species, including sandeel and herring, would be **minor adverse** significance (not significant; Chapter 11 Fish and Shellfish Ecology).

658. Potential sources of underwater noise and vibration during construction include piling, increased vessel traffic, seabed preparation, rock dumping and cable installation. Of these, piling is considered to produce the highest levels of underwater noise and therefore has the greatest potential to result in adverse impacts on fish. Underwater noise modelling (Appendix 5.3), assessed the following fish groups (based on Popper *et al*., 2014):

- No swim bladder (e.g. sole, plaice, lemon sole, mackerel and sandeels);
- Swim bladder not involved in hearing (e.g. sea bass, salmon and sea trout); and
- Swim bladder which is involved in hearing (e.g. cod, whiting, sprat and herring)

659. The underwater noise modelling results (Appendix 5.3) indicates that fish species in which the swim bladder is involved in hearing are the most sensitive to the impact of piling noise with impact ranges of up to 3.7km for mortality and potential mortal injury and up to 8.3km for recoverable injury, based on maximum potential ranges for cumulative exposure (SEL_{cum}).

660. Taking into account their wide distribution ranges, including areas used as spawning grounds, in the context of the potential ranges where TTS and behavioural impacts could occur, the assessment in Chapter 11 Fish and Shellfish Ecology, determined the potential impact to be of **minor adverse** significance.

661. As a precautionary worse-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be impacted as a result of changes to prey resources

during construction has been assessed based on the number of animals that could be present in the offshore wind farm areas and the offshore cable corridor (Table 12.51). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor. It is more likely that effects would be restricted to an area around the working sites. In addition, there would be no additional displacement of harbour porpoise as a result of any changes in prey resources during construction, as harbour porpoise would be potentially disturbed from the wind farm sites or cable corridor as a result of underwater noise during piling, other construction activities or vessels, as the potential area of effect would be less or the same as those assessed for piling, other construction activities or vessels.

662. Based on a more realistic, but precautionary approach that any changes in prey resource could occur affect up to 50% of the area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population), 19.5 grey seal (0.09% of reference population; 0.3% of the grey seal South-east England MU) and up to 12 harbour seal (0.03% of reference population; 0.2% of the harbour seal South-east MU) could be temporarily displaced.

663. The magnitude of effect in all species is **negligible**, for 100% or 50% displacement, with less than 1% of the reference population being likely to be temporarily affected (Table 12.51).

12.7.4.8.3 Impact significance

664. Taking into account the receptor sensitivity and the potential magnitude of the impact and the temporary nature of the disturbance, the impact significance for any changes in prey resource has been assessed as **negligible** (not significant) for grey seal and harbour seal and **negligible** to **minor adverse** (not significant) for harbour porpoise (Table 12.58); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1.

665. The confidence in the data used in this assessment is medium.

Table 12.58 Assessment of impact significance for any changes in prey resources on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Temporary changes to prey resources	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor	No further mitigation currently required, beyond embedded	**Negligible to Minor adverse**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour	Low	Negligible	Negligible		**Negligible**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
	seal				mitigation to reduce piling noise impacts.	

12.7.4.9 Impact 9: Changes to water quality

12.7.4.9.1 Sensitivity

666. Marine mammals often inhabit turbid environments and cetaceans utilise sonar to sense the environment around them and there is little evidence that turbidity affects cetaceans directly (Todd *et al*., 2014). Pinnipeds are not known to produce sonar for prey detection purposes; however, it is likely that other senses are used instead of, or in combination with, vision. Studies have shown that vision is not essential to seal survival, or ability to forage (Todd *et al*., 2014).

667. Increased turbidity is unlikely to have a substantial direct impact on marine mammals that often inhabit naturally turbid or dark environments. This is likely because other senses are utilised, and vision is not relied upon solely. Therefore, harbour porpoise, grey seal and harbour seal have **negligible** sensitivity to increases in suspended sediments during construction.

12.7.4.9.2 Magnitude

668. The risk of accidental release of contaminants (e.g. through spillage) will be mitigated through appropriate contingency planning and remediation measures for the control of pollution (see section 12.7.1). Therefore, the potential magnitude for any changes to water quality as a result of any accidental release of contaminants (e.g. through spillage or vessel collision) is **negligible** (see Chapter 9 Marine Water and Sediment Quality).

669. Disturbance of seabed sediments during construction has the potential to release any sediment-bound contaminants, such as heavy metals and hydrocarbons that may be present within them into the water column. However, data from the site specific surveys undertaken in 2016 indicates that levels of contaminants within NV East, NV West and the offshore cable corridor are very low. There were only two of the 13 locations sampled, exceeding Cefas Action Level 1 for concentrations of arsenic only, these exceedances are marginal as they are only just over the Action Level 1 concentration. All organotin and PCB results were below the limits of detection (0.004 mg/kg and 0.0001 mg/kg respectively). Therefore, the re-suspension of contaminated sediment from construction activities is anticipated to have a **negligible** impact (see Chapter 9 Marine Water and Sediment Quality).

670. There is the potential for increased suspended sediments as a result of construction activities, such as installation of foundations (for wind turbines, accommodation and electrical substation platforms), cable installation and during any levelling or dredging activities. However, as outlined in Chapter 8 Marine Physical Processes and Chapter 9 Marine Water and Sediment Quality, modelling indicates that the majority of the sediment released during seabed preparation would be coarse and would fall within minutes/ tens of minutes) to the seabed as a highly turbid dynamic plume immediately upon its discharge (within tens of metres along the axis of tidal flow).

671. The small proportion of fine sand/mud would stay in suspension for longer and form a passive plume. This plume (tens of mg/l) is likely to exist for around half a tidal cycle. Sediment would settle to the seabed within a few hundred metres up to around a kilometre along the axis of tidal flow, within a short period of time (hours). Within the passive plume, suspended solids concentrations were predicted to be within the range of natural variability. Suspended solids concentrations rapidly returned to background levels after cessation of the release into the water column. The deposits across the wider seabed would be very thin (millimetres) and would occur within Norfolk Vanguard. The assessment in Chapter 9 Marine Water and Sediment Quality determined that any changes in suspended sediment concentrations were **low** in magnitude due to the localised and short term nature of the predicted sediment plumes.

672. As a very precautionary approach the number of harbour porpoise, grey seal and harbour seal that could potentially encounter increased suspended sediments during construction has been assessed for the total offshore project area (Table 12.51). The magnitude of effect in all species is **negligible**, with less than 1% of the reference population being likely to be affected.

12.7.4.9.3 Impact significance

673. Taking into account the receptor sensitivity and the potential magnitude of the temporary impact, the impact significance for any increased suspended sediment during construction has been assessed as **negligible** (not significant) (Table 12.59); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1.

674. The confidence in the data used in this assessment is medium to high.

Table 12.59 Assessment of impact significance for changes to water quality during construction

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Increased suspended	Harbour porpoise	Negligible	Negligible	Negligible	No further mitigation	**Negligible**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
sediment in the total offshore project area	Grey seal	Negligible	Negligible	Negligible	proposed, other than embedded mitigation.	**Negligible**
	Harbour seal	Negligible	Negligible	Negligible		**Negligible**

12.7.5 Potential Impacts during Operation

675. All offshore infrastructure including wind turbines, foundations, cables and offshore substations would be monitored and maintained during the operation period in order to maximise efficiency.

12.7.5.1 Impact 1: Underwater noise from operational turbines

12.7.5.1.1 Sensitivity

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

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

678. Monitoring studies at Nysted and Rødsand have also suggested that operational activities have had no impact on regional seal populations (Teilmann *et al*., 2006; McConnell *et al*., 2012). Tagged harbour seals have been recorded within two operational wind farm sites (Alpha Ventus in Germany and Sheringham Shoal in UK) with the movement of several of the seals suggesting foraging behaviour around wind turbine structures (Russell *et al*., 2014).

679. Both harbour porpoise and seals have been shown to forage within operational windfarm sites (e.g. Lindeboom *et al*., 2011; Russell *et al*., 2014), indicating no restriction to movements in operational offshore windfarm sites. Therefore, harbour porpoise, grey seal and harbour seal are considered to have **low** sensitivity to disturbance from underwater noise as a result of operational turbines.

12.7.5.1.2 Magnitude

680. Noise levels generated by operational wind turbines are much lower than those generated during construction activities. Operational wind turbine noise mainly originates from the gearbox and the generator and has tonal characteristics (Madsen *et al*., 2006; Tougaard *et al*., 2009b). However, recordings of underwater noise are only available from a small number of operational wind farm sites. The main contribution to the underwater noise emitted from the wind turbines is expected to be from acoustic transfer of the vibrations of the substructure into the water rather than from transmission of in-air noise from the wind turbines into the water column (Lidell, 2003). Lidell (2003) concluded that noise levels of an operating wind farm would be too low to cause injury to marine mammals.

681. Touggard *et al*. (2009b) indicate that sound masking from operational noise is unlikely to impact harbour porpoise and seal acoustic communication, due to the low frequencies and low levels produced. Scheidat *et al*. (2011) reported an attraction of harbour porpoise to an operational Dutch wind farm site, where abundance was higher within the wind farm compared to a similar environment in near-by areas. This was assumed to be due to decreased fishing and vessel activity and increased food availability (Scheidat *et al*., 2011).

682. The Marine Management Organisation (2014) review found that available data on the operational turbine noise, from the UK and abroad, in general showed that noise levels radiated from operational wind turbines are low and the spatial extent of the potential impact of the operational wind turbine noise on marine receptors is generally estimated to be small, with behavioural response only likely at ranges close to the turbine. Although the early measured data were mainly for smaller capacity wind turbines ranging from about 0.2 to 2.0MW, more recently reported measured operational noise data from larger capacity wind turbines also showed noise levels and characteristics comparable with previous wind farms reported (MMO, 2014).

683. At the Naikun Offshore Wind Farm in British Columbia, JASCO (2009) predicted that sound pressure levels from the centre of the 396MW wind farm (110 x 3.6MW turbines) were greater than 120dB rms re 1 µPa SPL at ranges less than 8.5km.

684. Marmo *et al*. (2013) modelled the potential noise effects of operational offshore wind turbines, based on a generic 6MW wind turbine across the 10Hz to 2kHz

frequency band. The results for the monopile foundation indicated levels of 149 dB re 1 µPa SPL within 5m of the foundation at 560Hz. Modelling was also conducted to determine the potential sound field for a theoretical wind farm with 16 turbines at different wind speeds (5, 10 and 15 m/s). The results indicated that a wind farm with monopile foundations could be audible to marine mammals above background noise out to approximately 20km from the wind farm in all wind speeds (Marmo *et al.*, 2013). Based on the modelled results, potential behavioural response zones were calculated and harbour porpoise were only predicted to exhibit an aversive behavioural response using the M-weighting metric where 10% of animals encountering the noise field were expected to move away, at higher wind speeds the range was up to 18.84km. Avoidance ranges where 50% or 90% of porpoises were predicted to respond were not generated in any of the scenarios and therefore most harbour porpoises are not expected to respond to the operational noise. Neither seal species were predicted to exhibit a behavioural response to the sounds generated under any of the operational wind turbine scenarios (Marmo *et al.*, 2013).

685. Although turbine noise may be perceived as a loud sound it is unlikely that it would cause TTS and is therefore unlikely to cause permanent hearing damage in seals. Sound levels recorded at existing operational wind farms would also not cause hearing damage to harbour porpoise even at very short ranges. It is also unlikely that the low frequency tonal noise would mask the high frequency signals in harbour porpoise vocalisations (Marine Scotland, 2012).

686. The low-level noise generated during operation is likely to be detected by marine mammals over background noise levels only at short distances and below levels which would elicit a response (Madsen *et al.*, 2006; Thomsen *et al.*, 2006). The overall effect of the operational noise and the ability of marine mammals to perceive this noise will be largely dependent on ambient noise levels and wind speed. However, the operational wind turbines within the proposed project are not expected to result in increased noise levels more than a few kilometres from the site boundary.

687. As a precautionary worse-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be disturbed as a result of underwater noise from operational turbines has been assessed based on the number of animals that could be present in the offshore wind farm areas (Table 12.60). This is very precautionary, as it is highly unlikely that underwater noise from operational wind turbines could result in disturbance from the entire wind farm area. Therefore, values have been presented for three scenarios; 0% disturbance, as there is currently no evidence of any significant disturbance of harbour porpoise or seals from operational wind farm sites; a precautionary 50% disturbance; and a very worst-case of a 100% disturbance

from the offshore wind farm areas as a result of underwater noise from operational turbines. The potential effects of the underwater noise from operational turbines have been assessed for ‘long-term’ (not permanent) effects (Table 12.60).

Table 12.60 Estimated number of harbour porpoise, grey seal and harbour seal (and % of reference population) that could be disturbed from the Norfolk Vanguard offshore wind farm area during operation based on 100%, 50% and 0% disturbance as a result of operational turbine noise

Potential Impact Area	Receptor	Estimated number in potential impact area[1]			% of reference population[1]			Magnitude for long-term effects		
		100%	50%	0%	100%	50%	0%	100%	50%	0%
NV East area (297km^2)	Harbour porpoise	264 based on SCANS-III density (0.888/km^2) 374 based on density (1.26/km^2) at NV East.	132 based on SCANS-III density (0.888/km^2) 187 based on density (1.26/km^2) at NV East.	0	0.08% of NS MU based on SCANS-III density. 0.1% of NS MU based on density at NV East.	0.004% of NS MU based on SCANS-III density. 0.05% of NS MU based on density at NV East.	0	Long-term impact with **low** magnitude (between 0.01% and 1% of ref pop).	Long-term impact with **low** magnitude	None
	Grey seal	0.6 based on offshore wind farm area density (0.002/km^2)	0.3 based on offshore wind farm area density (0.002/km^2)	0	0.003% of ref pop (0.01% of SE England MU).	0.001% of ref pop (0.005% of SE England MU).	0	Long-term impact with **negligible** magnitude (less than 0.01% ref pop).	Long-term impact with **negligible** magnitude	None
	Harbour seal	0.03 based on offshore wind farm area density (0.0001/km^2)	0.015 based on offshore wind farm area density (0.0001/km^2)	0	0.00007% of ref pop (0.0006% of SE England MU).	0.00004% of ref pop (0.0003% of SE England MU).	0	Long-term impact with **negligible** magnitude.	Long-term impact with **negligible** magnitude	None
NV West area (295km^2)	Harbour porpoise	262 based on SCANS-III density (0.888/km^2)	131 based on SCANS-III density (0.888/km^2)	0	0.08% of NS MU based on SCANS-III density.	0.04% of NS MU based on SCANS-III density.	0	Long-term impact with **low** magnitude.	Long-term impact with **low** magnitude	None

Potential Impact Area	Receptor	Estimated number in potential impact area[1]			% of reference population[1]			Magnitude for long-term effects		
		100%	50%	0%	100%	50%	0%	100%	50%	0%
		233 based on density (0.79/km^2) at NV West.	116.5 based on density (0.79/km^2) at NV West.		0.07% of NS MU based on density at NV West.	0.03% of NS MU based on density at NV West.				
	Grey seal	0.6 based on offshore wind farm area density (0.002/km^2).	0.3 based on offshore wind farm area density (0.002/km^2)	0	0.003% of ref pop (0.01% of SE England MU).	0.001% of ref pop (0.005% of SE England MU).	0	Long-term impact with **negligible** magnitude.	Long-term impact with **negligible** magnitude	None
	Harbour seal	0.03 based on offshore wind farm area density (0.0001/km^2).	0.015 based on offshore wind farm area density (0.0001/km^2)	0	0.00007% of ref pop (0.0006% of SE England MU).	0.00004% of ref pop (0.0003% of SE England MU).	0	Long-term impact with **negligible** magnitude.	Long-term impact with **negligible** magnitude	None
Total offshore wind farm area (592km^2)	Harbour porpoise	526 based on SCANS-III density (0.888/km^2). 607 based on densities at each site.	263 based on SCANS-III density (0.888/km^2). 303.5 based on densities at each site.	0	0.2% of NS MU based on SCANS-III density. 0.2% of NS MU based on densities at each site.	0.08% of NS MU based on SCANS-III density. 0.09% of NS MU based on densities at each site.	0	Long-term impact with **low** magnitude	Long-term impact with **low** magnitude	None
	Grey seal	1 based on offshore wind farm area density (0.002/km^2).	0.5 based on offshore wind farm area density (0.002/km^2).	0	0.004% of ref pop (0.02% of SE England MU).	0.002% of ref pop (0.008% of SE England MU).	0	Long-term impact with **negligible** magnitude	Long-term impact with **negligible** magnitude	None

Potential Impact Area	Receptor	Estimated number in potential impact area[1]			% of reference population[1]			Magnitude for long-term effects		
		100%	50%	0%	100%	50%	0%	100%	50%	0%
	Harbour seal	0.06 based on offshore wind farm area density ($0.0001/km^2$).	0.03 based on offshore wind farm area density ($0.0001/km^2$).	0	0.0001% of ref pop (0.001% of SE England MU).	0.00007% of ref pop (0.0006% of SE England MU).	0	Long-term impact with **negligible** magnitude	Long-term impact with **negligible** magnitude	None

[1]Based on density estimates and reference populations (see Table 12.20 and Table 12.21); [2]See Table 12.7 for definitions

688. It is estimated that up to 526 harbour porpoise (0.2% of North Sea MU reference population), approximately one grey seal (0.004% of reference population or 0.02% of the South-east England MU) and 0.06 harbour seal (0.0001% of reference population or 0.0012% of the South-east England MU) could be present in the Norfolk Vanguard offshore wind farm sites (592km^2). For any 'long-term' (not permanent) effects, the magnitude is **low** for harbour porpoise and **negligible** for grey and harbour seal, based on 100% disturbance as a result of underwater noise from operational turbines.

12.7.5.1.3 Impact significance

689. Taking into account the potential 'long-term' (not permanent) effects, the impact significance for any disturbance as a result of operational turbines on harbour porpoise has been assessed as **minor adverse** (not significant) and as **negligible** (not significant) for grey seal and harbour seal (Table 12.61).

690. The confidence in the data used in this assessment is medium.

Table 12.61 Assessment of impact significance of underwater noise from operational turbines on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude for long-term effect	Significance for long-term effect	Mitigation	Residual impact
Disturbance from operational turbines	Harbour porpoise	Low	Low	Minor adverse	No mitigation required or proposed	**Minor adverse**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.7.5.2 Impact 2: Underwater noise from maintenance activities

12.7.5.2.1 Sensitivity

691. As outlined in section 12.7.4.2.4, the sensitivity of marine mammals to disturbance as a result of underwater noise during activities, such as cable installation, is considered to be **medium** in this assessment as a precautionary approach.

12.7.5.2.2 Magnitude

692. The requirements for any potential maintenance work, such as additional rock dumping or cable re-burial, are currently unknown, however the work required and associated impacts would be less than those during construction. The following estimates are assumed (Table 12.24):

- Reburial of all sections of array cable once every five years.
- One interconnector repair per year.

- Up to 20km of export cable reburial or 10km of reburial with 10km of rock dumping.

693. As outlined in section 12.7.4.3, the potential for TTS is only likely in very close proximity to cable laying or rock dumping activities, and noise generated should not be sufficient to cause PTS or other injury to marine mammals. Disturbance is the only potential noise impact from maintenance activities.

694. The impacts from additional cable laying and protection are temporary in nature, and will be limited to relatively short-periods during the operational and maintenance phase. Disturbance responses are likely to occur at significantly shorter ranges than construction noise. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

695. The magnitude of effect in all species is assessed to be **negligible** based on the total offshore project area (Table 12.51) and would be less than the magnitude of effect assessed for underwater noise for construction activities, other than piling (section12.7.4.3).

12.7.5.2.3 Impact significance

696. Taking into account the receptor sensitivity and the potential magnitude of the temporary impact, the impact significance for any disturbance of harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (not significant); therefore, no further mitigation measures are proposed beyond those embedded measures presented in section 12.7.1.

697. The confidence in the data used in this assessment is medium to high.

Table 12.62 Assessment of impact significance for underwater noise during maintenance activities

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Underwater noise during maintenance activities	Harbour seal	Medium	Negligible	Minor adverse	No mitigation required	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**

12.7.5.3 Impact 3: Vessel underwater noise and disturbance during operation and maintenance

12.7.5.3.1 Sensitivity

698. As outlined in section 12.7.4.4, the sensitivity of harbour porpoise, grey seal and harbour seal is **low** to vessel noise.

12.7.5.3.2 Magnitude

699. The requirements for any potential maintenance work are currently unknown, however the work required and impacts associated with underwater noise and disturbance from vessels during operation and maintenance would be less than those during construction. However, it estimated that there could be up to 480 support vessel round trips per year during operation and maintenance.

700. As outlined in section 12.7.4.4, the potential for TTS is only likely in very close proximity to vessels, and noise generated should not be sufficient to cause PTS or other injury to marine mammals. Disturbance is the only potential noise impact from vessels.

701. Taking into account the existing vessel movements in and around the Norfolk Vanguard area (see section 12.7.4.4) and the potential 1-2 vessel movement per day during operation and maintenance (Table 12.63) the number of vessels would not exceed the Heinänen and Skov (2015) threshold level of approximately 80 vessels per day. Therefore, there is no increase in the potential for disturbance to harbour porpoise as a result of the increased number of vessels during operation and maintenance at Norfolk Vanguard.

Table 12.63 Indicative operational and maintenance vessel movements

Parameter	Number of movements
Indicative total number of vessel movements per year	480
Average number of movements per day	1-2

702. The potential impacts as a result of underwater noise and disturbance from additional vessels during operation and maintenance from vessels would be short-term and temporary in nature. Disturbance responses are likely to be limited to the area in the immediate vicinity of the vessel. Marine mammals would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

703. The magnitude of effect in all species is assessed to be **negligible** (based on the number of animals in the total offshore project area (Table 12.51) and would be less

than the magnitude of effect assessed for underwater noise from vessels during construction (section 12.7.4.4).

12.7.5.3.3 Impact significance

704. Taking into account the receptor sensitivity and the potential temporary magnitude of the impact, the impact significance for any disturbance as a result of underwater noise from vessels during operation and maintenance on harbour porpoise, grey seal and harbour seal has been assessed as **negligible** (Table 12.64); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1.

705. The confidence in the data used in this assessment is medium to high.

Table 12.64 Assessment of impact significance for underwater noise from vessels during operation and maintenance activities

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Underwater noise from vessels during operation and maintenance activities	Harbour seal	Low	Negligible	Negligible	No mitigation required or proposed	**Negligible**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.7.5.4 Impact 4: Vessel collision risk

12.7.5.4.1 Sensitivity

706. As outlined in section 12.7.4.6, marine mammals in the Norfolk Vanguard area would be habituated to the presence of vessels and would be able to detect and avoid vessels. Therefore, harbour porpoise, grey seal and harbour seal are considered to have a **low** sensitivity to the risk of a vessel strike.

12.7.5.4.2 Magnitude

707. The operation and maintenance ports to be used for Norfolk Vanguard are not yet known and could be located on the south east coast of England. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is within the wind farm site and cable route. Indicative operational and maintenance vessel movements are provided in Table 12.63.

708. As outlined in section 12.7.4.6, Chapter 15 Shipping and Navigation, indicates relatively high shipping activity in and around Norfolk Vanguard. Therefore, based on the worst-case scenario of an average of two vessel movements per day (Table

12.63), the increase in vessels movement per day at the Norfolk Vanguard site (up to approximately 480 round trips per year) during operation and maintenance is relatively small compared to existing vessel traffic.

709. As a precautionary worst-case scenario approach the number of harbour porpoise, grey seal and harbour seal that could be at increased collision with vessels during operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (as assessed in section 12.7.4.6, Table 12.55).

710. This is very precautionary, as it is highly unlikely that all marine mammals present in the Norfolk Vanguard area would be at increased collision risk with vessels during operation and maintenance, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

711. The magnitude of effect for the potential increased collision from vessels is **medium** for harbour porpoise and **low** for grey and harbour seal (Table 12.55).

12.7.5.4.3 Impact significance

712. Taking into account the receptor sensitivity and the potential permanent magnitude of the impact (e.g. number of individuals as a percentage of the reference population), the impact significance for any potential increase in collision risk with vessels during operation and maintenance has been assessed as **minor adverse** (not significant) for harbour porpoise, grey seal and harbour seal (Table 12.65). No further mitigation measures are proposed beyond those embedded measures presented in section 12.7.1.

713. The confidence in the data used in this assessment is medium.

Table 12.65 Assessment of impact significance for increased collision risk from vessels during maintenance and operation

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Increased collision risk from vessels during construction for total offshore project area	Harbour porpoise	Low	Medium	Minor	No further mitigation proposed other than good practice.	**Minor adverse**
	Grey seal	Low	Low	Minor		**Minor adverse**
	Harbour seal	Low	Low	Minor		**Minor adverse**

12.7.5.5 Impact 5: Disturbance at seal haul-out sites

714. The Norfolk Vanguard offshore wind farm site is located approximately 47km offshore (at the closest point to NV West). Principal grey seal and harbour seal haul-out sites are at Horsey, 48km from the sites; Scroby Sands, approximately 46.5km; Blakeney Point, approximately 88km; The Wash, approximately 79km; and Donna Nook, approximately 149km from the Norfolk Vanguard offshore wind farm sites. The main breeding site for harbour seal on the east coast of England is in The Wash (SCOS, 2017). The main breeding site for grey seal on the east coast of England is at Blakeney Point (SCOS, 2017).

715. Taking into account the distances between the Norfolk Vanguard offshore wind farm site and the nearest seal haul-out sites, there is no potential for any direct disturbance as a result of operational and maintenance activities within the offshore wind farm sites.

716. The landfall at Happisburgh South is approximately 11km from the Horsey seal haul-out site to the south and 43km from the Blakeney Point haul-out site to the north. Given the distances between the Norfolk Vanguard cable route and landfall area and the nearest known seal haul-out sites; there is no potential for any direct disturbance as a result of operational and maintenance activities.

717. The operational and maintenance port to be used for Norfolk Vanguard is not yet known and could be located on the south east coast of England. Vessel movements to and from any port, where possible, will be incorporated within existing vessel routes. Vessel movements either to the windfarm or cable route would use direct routes and are unlikely to be close to the shore (i.e. within a few hundred metres) except when near the port to avoid the risk of collision and grounding. However, taking into account the proximity of shipping channels to and from existing ports, it is likely that any seals hauled-out along these routes and in the area of the ports would be habituated to the noise, movements and presence of vessels. There is therefore no potential for any direct disturbance at seal haul-out sites as a result of vessels moving to and from the windfarm sites and cable corridor, as vessels would not be moving at distances of 500m or less off the coast.

718. The potential for any increase in disturbance to seal haul-out sites as a result of operational and maintenance activities at the offshore wind farm sites, activities along the cable route and at the landfall site, or from vessel movements during operation and maintenance will be **negligible**.

12.7.5.5.1 Sensitivity

719. Taking into account the proximity of shipping channels to and from existing ports, it is likely that seals hauled-out along these routes and in the area of the ports would

be habituated to the noise, movements and presence of vessels. Therefore, the sensitivity of grey and harbour seals at haul-out sites to disturbance from vessels during construction is likely to be negligible. However, as a very precautionary approach, it is proposed that sensitivity during the breeding season and annual moult could be slightly higher and has therefore been considered as **low** in this assessment. The grey seal annual moult is between December and April and their breeding season is between early November and mid-December (see section 12.6.2.1.2). Harbour seal give birth to their pups in June and July and moult in August (see section 12.6.2.2.2).

12.7.5.5.2 Impact significance

720. Taking into account the receptor sensitivity and the potential magnitude of the impact and the temporary nature of the disturbance, the impact significance for any disturbance at seal haul-out sites during operation and maintenance has been assessed as **negligible** (not significant) (Table 12.66); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1.

721. The confidence in the data used in this assessment is medium to high.

Table 12.66 Assessment of impact significance for disturbance at seal haul-out sites during operation and maintenance

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Disturbance at seal haul-out sites during operation and maintenance	Grey seal	Low	Negligible	Negligible	No mitigation proposed or required	**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.7.5.6 Impact 6: Entanglement in floating foundations

12.7.5.6.1 Sensitivity

722. Harbour porpoise and seals have a high ability to avoid entanglement. The likelihood of marine mammals to become entangled in tension moorings lines is low due to the very low risk of the lines to become ‘looped’. Therefore, the sensitivity is determined to be **negligible**.

12.7.5.6.2 Magnitude

723. To date, there have been no recorded instances of marine mammal entanglement from mooring systems of renewable devices (Sparling *et al*., 2013; Isaacman and Daborn, 2011), or for anchored floating production, storage and offloading (FPSO)

vessels in the oil and gas industry (Benjamins *et al*., 2014) with similar mooring lines as proposed for floating turbine structures.

724. The level of risk to become entangled varies with species (Benjamins *et al*., 2014), these varying factors include:

- Body size;
- Flexibility of movement;
- The ability to detect mooring lines and ropes; and
- The feeding ecology of the species.

725. Toothed whales have a lower risk than baleen whales, primarily due to their small size and manoeuvrability. Seal species have a similar risk level to small toothed cetaceans, with an increase in manoeuvrability.

726. The proposed floating turbines for Norfolk Vanguard are Tension Leg Floating Platforms. Plate 12.9 below gives an indication of the design of these structures. Table 12.24 outlines the worst-case scenario for the use of floating platforms and mooring lines.

Plate 12.9 Indicative tension leg floating platforms

727. Taking into account the risk to each marine mammal species and the worst-case parameters for the tension mooring lines, it is unlikely for any marine mammal to become entangled within the floating turbines as all lines are taut at all times.

However, as a precautionary approach the magnitude has been assessed as **low** rather than negligible, given the limited information for entanglement in the tension mooring lines for floating wind turbines.

12.7.5.6.3 Impact significance

728. Taking into account the receptor sensitivity and the potential magnitude of the impact, the impact significance for the risk of entanglement has been determined to be **negligible** (Table 12.67); therefore, no mitigation measures are currently proposed, but this will be assessed further once the design has been finalised.

729. The confidence in the data used in this assessment is medium.

Table 12.67 Assessment of impact significance of entanglement in tension lines of floating turbines

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Entanglement in tension lines of floating turbines	Harbour porpoise	Negligible	Low	Negligible	No mitigation currently required or proposed	**Negligible**
	Grey seal	Negligible	Low	Negligible		**Negligible**
	Harbour seal	Negligible	Low	Negligible		**Negligible**

12.7.5.7 Impact 7: Changes to prey resource during operation and maintenance

12.7.5.7.1 Sensitivity

730. As outlined in section 12.7.4.8, grey seal and harbour seal are considered to have **low** sensitivity to changes in prey resources and, as a precautionary approach, harbour porpoise are considered to have **low** to **medium** sensitivity to changes in prey resources.

12.7.5.7.2 Magnitude

731. Potential impacts on marine mammal prey species have been assessed in Chapter 11 Fish and Shellfish Ecology using the appropriate realistic worst-case scenarios for these receptors.

732. Potential impacts on fish species during operation and maintenance can result from permanent loss of habitat; introduction of hard substrate; operational noise; and electromagnetic fields (EMF). None of the potential impacts are assessed as being significant (**minor adverse** at worst; Chapter 11 Fish and Shellfish Ecology).

733. As outlined in Chapter 11 Fish and Shellfish Ecology, in the OWF sites the worst-case total area of habitat loss has been estimated to be 11.6 (this would account for a very small proportion (2.0%) of the total OWF area). Similarly, the area of seabed

loss for the export cables would also be very small (0.15km^2), being limited to areas where cable protection measures may be required, particularly those associated with cable crossings. Therefore, with the low magnitude of effect, the impact of permanent loss of habitat was considered to be of **minor adverse** significance for fish species, including sandeels and herring (Chapter 11 Fish and Shellfish Ecology).

734. The introduction of hard substrate, such as turbines, foundations and associated scour protection and cable protection associated with Norfolk Vanguard would increase habitat heterogeneity through the introduction of hard structures in an area predominantly characterised by soft substrate habitat. However, any hard substrate would occupy discrete areas and given the relatively small areas of the infrastructure will result in a low magnitude of the effect, therefore the impact is considered to be of **minor adverse** significance.

735. Operational noise would include wind turbine vibration, the contact of waves with offshore structures and noise associated with increased vessel movement, which could result in an increase in underwater noise in respect of the existing baseline (i.e. pre-construction). However, based on studies at other offshore wind farms, any increase above background noise levels during operation is expected to be small and localised, therefore the magnitude of the impact on fish species would be low, resulting in a potential impact of **minor adverse** significance.

736. As outlined in Chapter 11 Fish and Shellfish Ecology, the areas potentially affected by EMFs generated by the worst-case scenario offshore cables are expected to be small, limited to the area of the OWF sites and the offshore cable corridor and restricted to the immediate vicinity of the cables (i.e. within metres). In addition, EMFs are expected to attenuate rapidly in both horizontal and vertical plains with distance from the source. The magnitude of the effect on fish species is therefore considered to be low and the impact of EMFs of **minor adverse** significance (Chapter 11 Fish and Shellfish Ecology).

737. As a precautionary worst-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be impacted as a result of changes to prey resources during operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 12.61). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor during operation and maintenance.

738. However, based on this very precautionary approach, the magnitude of effect in all species is **negligible**, with less than 1% of the reference population being likely to be affected. As outlined in Table 12.51, it is estimated that approximately 891 harbour

porpoise (0.3% of the North Sea MU reference population) could be present in the wind farm sites and offshore cable corridor area (based on the maximum density estimate). There is an estimated 39 grey seal and 24 harbour seal that could be present, primarily in the offshore cable corridor area (based on seal-at sea density maps; Russell *et al*., 2017), which is 0.2% of the grey seal reference population (0.6% of the grey seal South-east England MU) and 0.006% of the harbour seal reference population (0.5% of the South-east England MU for harbour seal) (Table 12.51).

12.7.5.7.3 Impact significance

739. Taking into account the receptor sensitivity and the potential temporary magnitude of the impact, the impact significance for any changes in prey resource has been assessed as **negligible** (not significant) for grey seal and harbour seal and **negligible** to **minor adverse** (not significant) for harbour porpoise (Table 12.68); therefore no further mitigation measure are proposed beyond those embedded measures presented in section 12.7.1.

740. The confidence in the data used in this assessment is medium.

Table 12.68 Assessment of impact significance of changes in prey resources on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Changes to prey resources	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor	No mitigation required or proposed	**Negligible to Minor adverse**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.7.6 Potential Impacts during Decommissioning

741. Possible effects on marine mammals associated with the decommissioning stage(s) have been assessed; however, a further assessment will be carried out ahead of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements.

12.7.6.1 Impact 1: Underwater noise from foundation removal

742. Decommissioning would most likely involve removal of the accessible installed components comprising: all of the wind turbine components; part of the foundations (those above sea bed level); and the sections of the inter-array cables close to the offshore structures, as well as sections of the export cables. The process for removal

of foundations is generally the reverse of the installation process. There would be no piling, and foundations may be cut to an appropriate level.

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

744. A detailed decommissioning plan will be provided prior to decommissioning that will give details of the techniques to be employed and any relevant mitigation measures required.

745. For this assessment it is assumed that the potential impacts from underwater noise during decommissioning would be less than those assessed for piling (section 12.7.4.2) and comparable to those assessed for other construction activities (section 12.7.4.3).

12.7.6.2 Impact 2: Barrier effects from underwater noise

746. For this assessment it is assumed that the potential impacts from any barrier effects during decommissioning would be less than those assessed for construction (section 12.7.4.5).

12.7.6.3 Impact 3: Vessel underwater noise and disturbance from vessels

747. For this assessment it is assumed that the potential impacts would be the same as for construction (see section 12.7.4.4).

12.7.6.4 Impact 4: Vessel collision risk

748. For this assessment it is assumed that the potential impacts would be the same as for construction (see section 12.7.4.6).

12.7.6.5 Impact 5: Disturbance at seal haul-out sites

749. For this assessment it is assumed that the potential impacts would be the same as for construction (see section 12.7.4.7).

12.7.6.6 Impact 6: Changes to prey resource

750. For this assessment it is assumed that the potential impacts would be the same as for construction (see section 12.7.4.8).

12.7.6.7 Impact 7: Changes to water quality

751. For this assessment it is assumed that the potential impacts would be the same as for construction (see section 12.7.4.9).

12.8 Cumulative Impacts

752. As outlined in section 12.4.2, the CIA considers plans or projects where the predicted impacts have the potential to interact with impacts from the proposed construction, operation and maintenance or decommissioning of Norfolk Vanguard.

753. The plans and projects screened in to the CIA (see Appendix 12.3) are located in the relevant marine mammal reference population areas for harbour porpoise, grey seal and harbour seal (as defined in Table 12.20).

12.8.1 Project Tiers

754. The types of plans and projects included in the CIA, and the approach to screening, are based on the current stage of the plan or project within the planning and development process. This approach allows for the different levels of 'uncertainty' to be taken into account on the CIA, as well as the quality of the data available. This approach and definitions of the Tiers used (as outlined in section 12.4.2) was agreed at the EPP meeting in February 2017 (Table 12.4).

12.8.1.1 Tier 1 and Tier 2 projects

755. Tier 1 projects are relevant operational projects and therefore there is no potential for any overlap in the construction and piling of these projects with the construction and piling at Norfolk Vanguard.

756. The CIA screening identified 23 UK and 34 European Tier 1 OWFs that could have possible cumulative operational, maintenance and decommissioning impacts (see Appendix 12.3).

757. Seven Tier 1 wave and tidal projects (two wave and five tidal) were identified, which could have possible cumulative operational, maintenance and decommissioning impacts (Appendix 12.3).

758. Tier 2 projects are marine infrastructure projects currently under construction and which are due to be commissioned prior to the construction of Norfolk Vanguard, therefore there is no potential for any overlap in the construction and piling of these projects with the construction and piling at Norfolk Vanguard.

759. The CIA screening identified five UK and two European Tier 2 OWFs that could have possible cumulative operational, maintenance and decommissioning impacts (Appendix 12.3).

760. Ten Tier 2 subsea cables and pipelines projects were identified which could have cumulative impacts during their installation (Appendix 12.3).

12.8.1.2 Tier 3 projects

761. Tier 3 projects are relevant marine infrastructure projects which have been consented, but for which construction has not yet commenced. Therefore, there is more certainty that these projects will be constructed compared to projects for which an application has not yet been determined. For Tier 3 OWF projects there is also more information on when construction is likely to be undertaken and an assessment of the potential impacts during piling have been provided in the project ESs, which allows quantified assessment of the potential impacts of these projects in the CIA.

762. However, there is still significant uncertainty associated with these projects, for example, in terms of the scale of the final development which will be constructed, precise construction dates and the likely final impacts. In particular, OWF projects aim to get consent for a maximum design scenario, based on the worst-case parameters, and then these parameters are generally refined and reduced post consent.

763. The CIA screening identified 13 UK Tier 3 OWFs, of which 9 projects could have possible cumulative impacts during construction and all 13 could have possible cumulative operational, maintenance and decommissioning impacts (Appendix 12.3).

764. The CIA screening identified 31 European Tier 3 OWFs, of which seven projects could have possible cumulative impacts during construction and all 31 could have possible cumulative operational, maintenance and decommissioning impacts (Appendix 12.3).

765. One Tier 3 tidal project was identified which could have possible operational, maintenance and decommissioning impacts (see Appendix 12.3).

12.8.1.3 Tier 4 projects

766. Tier 4 projects are relevant marine infrastructure projects which have an application submitted to the appropriate regulatory body but that have not yet been determined or are consented but currently on hold due to judicial challenge or appeal process. There is increased uncertainty about these projects, especially where the projects are currently on-hold, as to when or if they could be constructed and what changes could be made to the scale of the developments.

767. The CIA screening identified five UK Tier 4 OWFs which could have possible cumulative impacts during construction, operational, maintenance and decommissioning impacts (Appendix 12.3).

768. One Tier 4 tidal project was identified which could have possible operational, maintenance and decommissioning impacts (Appendix 12.3).

769. Five Tier 4 subsea cables and pipelines projects were identified which could have cumulative impacts during their installation (Appendix 12.3).

12.8.1.4 Tier 5 projects

770. Tier 5 projects are relevant marine infrastructure projects that the regulatory body are expecting to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects).

771. As outlined in Table 12.10, Tier 5 projects were screened out of the CIA, as there is just too much uncertainty and not enough information to allow a robust assessment. However, as a very precautionary approach, the Tier 5 UK OWF projects that we are currently aware of have been listed and included in the 'worst-case' scenario for cumulative impacts during OWF piling (see section 12.8.1.1).

772. The CIA screening identified six UK Tier 5 OWFs which could have possible cumulative impacts during construction, operation, maintenance and decommissioning (Appendix 12.3).

773. One potential Tier 5 pipelines project was identified which could have cumulative impacts during installation (Appendix 12.3).

12.8.2 Types of Cumulative Impacts and Approach to Assessment

774. Types of impact considered in the CIA are summarised in Table 12.69. The CIA considers the three types of impact (underwater noise, indirect impacts and direct interaction) from all stages of any plan or project where there is the potential to overlap with Norfolk Vanguard. Each type of potential cumulative impact has been assessed, where relevant, for harbour porpoise, grey seal and harbour seal.

12.8.2.1 Underwater noise

775. The potential sources of underwater noise during each stage of a plan or project are summarised in Table 12.69.

776. Auditory injury (PTS) could occur as a result of pile driving during offshore wind farm installation, pile driving during oil and gas platform installation, underwater explosives (used occasionally during the removal of underwater structures and UXO clearance) and seismic surveys (JNCC, 2010a, 2010b, 2017a). However, if there is the potential for any auditory injury (PTS), suitable mitigation would be put in place to reduce any risk to marine mammals. Other activities such as dredging, drilling, rock dumping and disposal, vessel activity, operational wind farms, oil and gas installations or wave and tidal sites will emit broadband noise in lower frequencies

and auditory injury (PTS) from these activities is very unlikely. Therefore, the potential risk of any auditory injury (PTS) in marine mammals is not included in the CIA.

777. The CIA assessment determines the potential for disturbance to marine mammals from underwater noise sources during the construction period, operational and maintenance period and decommissioning of Norfolk Vanguard.

778. The approach to the assessment for cumulative disturbance from underwater noise has been based on the approach in section 12.7.4.2.4 and follows the current advice from the SNCBs on the assessment of impacts on the SNS harbour porpoise cSAC. This approach has been used for the Norfolk Vanguard EIA, including the CIA.

779. Following the current advice from the SNCBs, the CIA has been based on the following parameters:

- A distance of 26km from an individual percussive piling location has been used to assess the area that harbour porpoise, grey seal and harbour seal could potentially be disturbed during piling, for both single and concurrent piling operations.
- A distance of 10km around seismic operations has been used to assess the area that harbour porpoise, grey seal and harbour seal could potentially be disturbed.
- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise, grey seal and harbour seal could potentially be disturbed.

780. The potential disturbance from underwater noise has been assessed for the relevant plans and projects screened in to the CIA, based on these standard disturbance areas for piling, seismic surveys and UXO clearance.

781. The potential disturbance from OWFs during construction activities other than pile driving noise sources, including vessels, seabed preparation, rock dumping and cable installation, has been based on the area of the OWF sites, as outlined in section 12.7.4.3 and section 12.7.4.4; this is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity and other noisy activities including the operation of large vessels, rock dumping or cable burial would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

782. The potential disturbance from operational OWFs and maintenance activities, including vessels, any rock dumping or cable re-burial, has been based on the area of the OWF sites, as outlined in section 12.7.5.2 and section 12.7.5.3; this is again a precautionary approach, as it is highly unlikely that operational OWFs and maintenance activities, including vessels, would result in disturbance from the entire

wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

783. Where a quantitative assessment has been possible, the potential magnitude of disturbance in the CIA has been based on the number of harbour porpoise in the potential impact area using the latest SCANS-III density estimates (Hammond *et al*., 2017) for the area of the projects. The number of grey and harbour seal in the potential impact area has been estimated based on the latest seal at sea usage maps (Russell *et al*., 2017) for the area of the projects.

784. It is intended that this approach to assessing the potential cumulative impacts of disturbance from underwater noise will reduce some of the uncertainties and complications in using the different assessments from ESs, based on different noise models, thresholds and criteria, as well as different approaches to density estimates, etc.

12.8.2.2 Changes in prey availability

785. The CIA determines the potential for any changes to prey availability for marine mammals from underwater noise sources during the construction period, operational and maintenance period and decommissioning of Norfolk Vanguard.

786. The potential changes to prey availability for OWFs, during construction, operation and maintenance, and decommissioning has used a similar precautionary approach as outlined in section 12.7.4.8 and section 12.7.5.7. Any potential changes in prey availability, as a result of any EMF effects, noise and vibration, changes or loss of habitat, physical disturbance, increased suspended sediments and sediment re-deposition, has been assessed based on the wind farm area. This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area. It is more likely that effects would be restricted to an area around the areas of activity and / or infrastructure.

787. Where a quantitative assessment has been possible, the potential magnitude of any changes to prey availability has been based on the number of harbour porpoise in the potential impact area using the latest SCANS-III density estimates (Hammond *et al*., 2017) for the area of the projects. The number of grey and harbour seal in the potential impact area has been estimated based on the latest seal at sea usage maps (Russell *et al*., 2017) for the area of the projects.

12.8.2.3 Increased collision risk

788. As outlined in section 12.7.4.6, it is difficult to quantify the increased collision risk to marine mammals.

789. The potential increased collision risk with vessels during the construction and decommissioning of OWFs has used a similar precautionary approach as outlined in section 12.7.4.6 and section 12.7.5.4. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is within the wind farm site. Therefore, the number of harbour porpoise, grey seal and harbour seal that could be at increased collision risk with vessels has been assessed based on the number of animals that could be present in the wind farm areas taking into account 95% avoidance rates. This is very precautionary, as it is highly unlikely that all marine mammals present in the wind farm areas would be at increased collision risk with vessels.

790. Where a quantitative assessment has been possible, the number of harbour porpoise in the potential impact area has been determined using the latest SCANS-III density estimates (Hammond *et al*., 2017) for the area of the projects, taking into account 95% avoidance rates. The number of grey and harbour seal in the potential impact area has been estimated based on the latest seal at sea usage maps (Russell *et al*., 2017) for the area of the projects, taking into account 95% avoidance rates.

12.8.3 Considerations for CIA

791. It should be noted that a large amount of uncertainty is inherent in the completion of a CIA. At the project level, uncertainty in the assessment process has been expressed as a level of the confidence in the data used in the assessment. This relates to confidence in both the understanding of the consequences of the impacts in marine mammals, but also the information used to inform the predicted magnitude and significance of project impacts on marine mammals.

792. In the CIA, the potential for impacts over wider spatial and temporal scales means that the uncertainty arising from the consideration of a large number of plans or projects can lead to a lower confidence in the information used in the assessment, but also the conclusions of the assessment itself. To take this uncertainty into account, where possible, a precautionary approach has been taken at multiple stages of the assessment process.

793. The approach to dealing with uncertainty has led to a highly precautionary assessment of the cumulative impacts, especially for pile driving as the CIA is based on the worst-case scenarios for all projects being required, e.g. concurrent piling with no overlap. However, it should be noted that building precaution on precaution can lead to unrealistic worst-case scenarios within the assessment.

794. Therefore, the assessment will be based on the most realistic worst-case scenario (the ‘potential worst-case’ scenario), to help reduce any uncertainty and present

highly unrealistic worst-case scenarios while still providing a conservative assessment. Careful consideration has been undertaken to determine this 'potential worst-case' scenario for the cumulative impact assessment. It was agreed with the ETG on the EPP call on 8th December 2017, that the 'likely/potential worst-case scenario' presented in the PEIR was appropriate for the assessment in the ES (Table 12.4), with the 'theoretical worst-case' presented in Appendix 12.6.

795. The aim of the CIA is to achieve a more evidence based and realistic assessment of the potential cumulative population effects as a result of the disturbance to harbour porpoise from piling noise.

796. The level of uncertainty in completing a CIA further supports the need for a more strategic level assessment rather than developer led assessment. Population models, such as Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea (DEPONS) and the interim Population Consequences of Disturbance (iPCoD) used at a strategic level would allow consideration of the biological fitness consequences of disturbance from underwater noise, and the conclusions of a quantitative assessment to be put into a population level context (e.g. Nabe-Nielsen *et al.*, 2018). Norfolk Vanguard Limited is supportive of these strategic initiatives, and will continue to work alongside other developers, Regulators and SNCBs in order to further understand the potential for significant cumulative impacts, and lead to reductions in impacts where appropriate.

Table 12.69 Impacts considered within the CIA

Impact	Sources of impact and stages of projects	Potential cumulative effects
Underwater Noise - disturbance	Pile driving noise: • Construction	Cumulative increase in underwater noise from piling during construction at offshore developments has the potential to cause disturbance to marine mammals. Included in the CIA: - Projects with overlapping construction phases with Norfolk Vanguard, resulting in maximum potential for underwater piling noise to interact cumulatively in the regional marine mammal reference population boundaries. o Worst case temporal adverse scenario considers the longest duration of the piling phase for each of the projects. This may include projects whose construction phases do not overlap with Norfolk Vanguard but which occur immediately prior to or after and therefore increase the overall duration of sequential piling within the marine mammal reference population boundaries. o Maximum spatial adverse scenario considers the maximum area of which marine mammal could be disturbed as a result of offshore piling.
	Vessel noise: • Construction; • Operation and maintenance; and • Decommissioning	Cumulative increase in vessel traffic arising from construction, operation and maintenance and decommissioning of offshore developments may result in increased noise disturbance to marine mammals. Included in the CIA: - Projects with overlapping construction phases with Norfolk Vanguard, resulting in maximum increase in number of vessel movements. - Projects that could contribute to increased vessel traffic due to operational and maintenance or decommissioning activities.
	Other noise sources: seabed preparation / rock dumping; cable or pipe laying; surveying, including seismic surveys; drilling; disposal noise; dredging noise; wind turbine or other mechanical operational noise; foundation / cable removal; UXO clearance and explosives: • Construction; • Operation and maintenance; and • Decommissioning	Cumulative increase in noise for activities other than piling and vessels arising from construction, operation and maintenance and decommissioning of offshore developments may result in increased noise disturbance to marine mammals. Included in the CIA: - Projects with overlapping construction phases with Norfolk Vanguard, resulting in maximum potential impacts on marine mammals. - Projects that could have the potential to disturb marine mammals due to operational and maintenance or decommissioning activities.

Impact	Sources of impact and stages of projects	Potential cumulative effects
Indirect impact – changes in prey availability	Temporary or long term loss / changes in habitats; disturbance from underwater noise (sources as outlined above); increased suspended sediments/sediment deposition; EMF emitted by subsea cables: • Construction; • Operation and maintenance; and • Decommissioning	Cumulative changes in fish abundance and distribution resulting from construction, operation and maintenance, and decommissioning of offshore developments may lead to a loss or changes in prey resources for marine mammals. Included in the CIA: - Projects with overlapping construction phases with Norfolk Vanguard, resulting in maximum potential impacts on prey species. - Projects that could contribute to changes in prey resources due to operational and maintenance or decommissioning activities.
Direct interaction – increased collision risk	Vessels (hull impacts, ducted propellers): • Construction; • Operation and maintenance; and • Decommissioning Wave and tidal devices: • Operation	Cumulative increase in vessel traffic arising from construction, operation and maintenance, and decommissioning of offshore developments may result in increased collision risk to marine mammals. Included in the CIA: - Projects with overlapping construction phases with Norfolk Vanguard, resulting in maximum increase in number of vessel movements in the regional marine mammal study area. - Projects that could contribute to increased vessel traffic due to operational and maintenance or decommissioning activities.

12.8.4 Impact 1: Underwater noise impacts during construction from OWF piling

797. The greatest noise source is likely to result from pile driving during the construction of offshore wind farms. This stage of the cumulative assessment of underwater noise considers the potential disturbance of marine mammals during piling at Norfolk Vanguard and piling at other OWF projects screened into the CIA that could potentially be piling at the same time.

798. Two scenarios for assessing the potential cumulative impacts of disturbance due to underwater noise from piling during offshore wind farm construction have been assessed:

- The assessment has been undertaken based on the 'potential worst-case' scenario of the offshore wind farm developments that could be piling at the same time as Norfolk Vanguard. This scenario is based on a precautionary approach using the maximum duration of piling periods.
- In addition, a 'theoretical worst-case', scenario based on consent periods which allows for any delays and changes in project development has been assessed in Appendix 12.6.

799. The UK Tier 3, 4 and 5 OWF projects and European Tier 3 OWF projects are included in the potential worst-case scenario to assess the potential for cumulative disturbance of marine mammals during OWF piling, based on the periods of piling are outlined in Table 12.70.

800. The potential worst-case scenario takes into account the most likely and most efficient build scenarios, based on certain assumptions e.g. developers of more than one site are unlikely to develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site. It has therefore been assumed that there will be no overlap in the piling of Norfolk Vanguard and Norfolk Boreas, or between the East Anglia THREE, ONE North and TWO projects, and that two of the Dogger Bank projects could be constructed at the same time (as they now have different developers).

801. As a highly precautionary approach Appendix 12.6 includes a further iteration adding Norfolk Boreas to the potential worst-case scenario.

802. The CIA has been based on single or concurrent piling in NV West.

803. For the CIA, the potential construction period of Norfolk Vanguard has been based on the widest likely range of construction dates of between 2024 and 2028, based on a four year construction period.

804. As a precautionary worst-case it has been assumed that piling could occur at any time during the potential construction period, although would not be continuous for the duration of the construction period. As outlined in section 12.7.4.2.4, active piling and ADD activation would only be for a relatively short period, up to 58 days, approximately 4% of the four year construction period.

805. These figures are typical of offshore wind projects and when comparing the potential cumulative impact of several projects it is important to note that the likelihood of several projects all piling at the same time is comparatively low as the length of piling time per project construction period is very low (typically in the order 3-5% depending on construction programme). The risk of concurrent piling occurring is also affected by other factors including seasonality, vessel market conditions and by weather in the North Sea.

Table 12.70 Offshore wind farms included in cumulative impact assessment (CIA) for the potential disturbance of harbour porpoise, grey seal and harbour seal where there is the potential of piling occurring at the same time as piling at Norfolk Vanguard. All details presented are based on the most up to date information for each project at the time of writing.

Name and country of project	Distance from NV	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (7yr construction window)	Dates of offshore construction / piling[1]	Potential worst-case scenario of piling occurring at the same time as Norfolk Vanguard piling[2]
Norfolk Vanguard	**0**	**1,800**	**120-257**	**2019 (2019-2024)**	**Construction and piling: 2024 – 2028**	**Yes**
Tier 3: consented						
Creyke Beck A, UK	163	500-600	200	Feb-15 (2015-2022)	2021-2027	No[3]
Creyke Beck B, UK	193	500-600	200	Feb-15 (2015-2022)	2021-2028	**Yes**[3]
Teesside A, UK	180	1,200	200	Aug-15 (2015-2022)	2021-2028	**No**[3]
Sophia (formerly Teesside B), UK	175	1,200	200	Aug-15 (2015-2022)	2020-2028	**Yes**[3]
East Anglia One, UK	40	714	102	Jun-14 (2014-2021)	Piling: 2018-2019	No
East Anglia THREE, UK	0	1,200	172	Aug-17 (2017-2024)	Piling: 2020 – 2022	No
Hornsea Project Two, UK	95	1,800	225	Aug-16 (2016-2023)	2018-2021 Piling: 2018-2020	No
Triton Knoll phase 1-3, UK	288	1,200	288	Jul-13 (2013-2020)	2018-2021	No
Kincardine	535	49.6	8	2017 (2017-2024)	2018-2019	No
Mermaid (Belgium)	125	366-288	24-48	2015 (2015-2022)	2017-2019	No

Name and country of project	Distance from NV	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (7yr construction window)	Dates of offshore construction / piling[1]	Potential worst-case scenario of piling occurring at the same time as Norfolk Vanguard piling[2]
Norfolk Vanguard	**0**	**1,800**	**120-257**	**2019 (2019-2024)**	**Construction and piling: 2024 – 2028**	**Yes**
Northwester 2 (Belgium)	130	224	22-38	2015 (2015-2022)	Unknown	No
Delta Nordsee 1 (Germany)	300	210	35	2005	Piling to commence in 2023	No
Delta Nordsee 2 (Germany)	300	192	32	2009	Piling to commence in 2023	No
Borssele I and II (Netherlands)	133	350+350	95+95	May-16 (2016-2023)	2019	No
Borssele III and IV (Netherlands)	123	360+340	95+95	May-16 (2016-2023)	2020	No
Borssele Site V - Leeghwater - Innovation Plot (Netherlands)	108	20	2	May-16 (2016-2023)	2020	No
Tier 4: application submitted and project on-hold						
Firth of Forth Phase 1 Seagreen Alpha and Bravo, UK	500	1,050	150	Oct-14 (2014-2021)	Unknown – on-hold	No
Inch Cape, UK	510	784	110	Oct-14 (2014-2021)	Unknown – on-hold	No
Neart na Gaoithe, UK	475	448	75	Oct-14 (2014-2021)	Unknown – on-hold	No
Moray Firth Western Development Area	660	750	90	2014 (2014-2021)	Unknown – on-hold	No
Dounreay Tri	785	10	2	2017 (2017-2024)	Unknown – project postponed	No
Tier 5: application in preparation						
Norfolk Boreas	30	1,800	257	2019 TBC (2019-2026)	Possible piling: 2025-2029	No[4]

Name and country of project	Distance from NV	Size (MW)	Maximum number of turbines	Month/year consent authorised/ expected (7yr construction window)	Dates of offshore construction / piling[1]	Potential worst-case scenario of piling occurring at the same time as Norfolk Vanguard piling[2]
Norfolk Vanguard	**0**	**1,800**	**120-257**	**2019 (2019-2024)**	**Construction and piling: 2024 – 2028**	**Yes**
Hornsea Project Three	88	2,400	342	2018 TBC (2018-2025)	Possible piling: 2022-2023 and 2029-2030	Yes
Thanet Extension	165	340	34	2018 TBC (2018-2025)	2020-2023	No[4]
East Anglia ONE North	30	Up to 800	Up to 67		2026 - 2029	No[5]
East Anglia TWO	45	Up to 900	Up to 75		2025 - 2029	Yes[5]

[1]Piling and offshore construction dates are based on the latest dates and information available.

[2] Potential worst-case scenarios: projects for which consent has been granted (Tier 3 projects) and proposed piling is likely to overlap with the proposed piling of Norfolk Vanguard.

[3]It is highly unlikely that all four Dogger Bank projects would be piling at the same time; therefore, the two projects that could be constructed at the same time (i.e. they have different developers) have been included in the potential worst-case scenario.

[4] Based on the most efficient and most likely build scenario and as outlined in Section 8.4, to limit the potential for in-combination disturbance effects, taking into account the current SNCB guidance for the assessment of the potential effects on the Southern North Sea cSAC for harbour porpoise, concurrent piling with Norfolk Boreas and Thanet Extension would be avoided where possible, subject to construction milestones associated with The Crown Estate Agreement for Lease.

[5] Based on the most efficient and most likely build scenario, SPR would construct only one site at a time, with EA1N following EA2.

12.8.4.1 Potential disturbance of harbour porpoise during OWF piling

806. The commitment to the mitigation measures agreed through the MMMP for piling would result in no potential effects for lethal injury, physical injury and permanent auditory injury (PTS). As such, the proposed Norfolk Vanguard project would not contribute to any cumulative impacts for lethal injury, physical injury and permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

12.8.4.1.1 Sensitivity to disturbance

807. As outlined in section 12.7.4.2.4, harbour porpoise are assessed as having **medium** sensitivity to disturbance from underwater noise sources (Table 12.36).

12.8.4.1.2 Magnitude of cumulative impacts

808. The magnitude of the potential disturbance of harbour porpoise has been estimated for each individual project based on:

- The potential impact area during single pile installation, based on a radius of 26km from each piling location (2,124km^2 per project); and
- The potential impact area during concurrent pile installation, based on a radius of 26km from two piling locations per project with no overlap in impact areas (4,248km^2 per project).

809. It should be noted that the potential areas of disturbance have not taken into account the potential overlap in the areas of disturbance between different projects, and are therefore highly conservative.

810. For each project, the number of harbour porpoise in the potential impact areas, for single and concurrent piling, has been estimated using the latest SCANS-III density estimates (Hammond *et al.*, 2017) for the relevant survey block that the project is located within.

811. The conservative potential worst-case scenario for OWFs that could be piling at the same time as Norfolk Vanguard in the North Sea MU includes four other UK OWFs (Table 12.70):

- Creyke Beck B
- Sofia
- Hornsea Project 3
- East Anglia TWO

812. In this potential worst-case scenario, for concurrent piling the estimated maximum area of potential disturbance is 21,240km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms. The maximum number of harbour porpoise that could potentially be temporarily disturbed is

17,667 individuals, which represents approximately 5% of the North Sea MU reference population (Table 12.71). Therefore, the magnitude would be **medium** for harbour porpoise (with between 5% and 10% of the reference population anticipated to be exposed to the effect). However, this is very precautious, as it is unlikely that five projects could be concurrently piling at exactly the same time.

813. Based on a single pile installation at each of the five OWFs, the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms. The maximum number of harbour porpoise that could potentially be temporarily disturbed is 8,833 individuals which represents approximately 3% of the North Sea MU reference population (Table 12.71). Therefore, the potential magnitude of the temporary effect is assessed as **low**, with between 1% and 5% of the reference population likely to be exposed to the effect.

814. The approach to the CIA, based on the five UK OWFs single piling, would allow for some of these sites not to be piling at the same time while others, including Norfolk Vanguard, could be concurrent piling.

815. As outlined above, although the potential piling duration for Norfolk Vanguard has been assessed based on a precautionary maximum duration for construction, the actual piling time and ADD activation which could disturb harbour porpoise is only a very small proportion of this time, of up to approximately 58 days, approximately 4% of the estimated four year construction period, based on the estimated maximum duration to install individual piles.

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

Table 12.71 Quantified CIA for the potential disturbance of harbour porpoise during single and concurrent piling of OWFs for the potential worst-case scenario based on the OWF projects which could be piling at the same time as Norfolk Vanguard.

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Potential number of harbour porpoise disturbed during single piling (2,124km^2)	Potential number of harbour porpoise disturbed during concurrent piling with no overlap (4,248km^2)
Norfolk Vanguard	5	0	O[1]	0.888	1,886	3,772
Creyke Beck B	3	193	O	0.888	1,886	3,772
Sofia	3	180	O[2]	0.837	1,886	3,772
Hornsea Project THREE	5	80	O	0.888	1,886	3,772
East Anglia TWO	5	45	L	0.607	1,289	2,579
Total					**8,833**	**17,667**
% of North Sea MU reference population (345,373 harbour porpoise)					**2.6%**	**5.1%**

[1]NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore, higher density estimate from survey block O is used.
[2]Sofia overlaps SCANS-III survey block O & N, but majority of site is in block O.

12.8.4.1.3 Cumulative impact significance

817. Taking into account the **medium** receptor sensitivity and the **low** potential magnitude of the cumulative impact, the overall assessment of **minor adverse** (not significant impact) is deemed to be a conservative assessment based on the potential worst-case scenario for four offshore wind farms single piling at the same time as Norfolk Vanguard (Table 12.72).

818. If all four offshore wind farms were concurrent piling at the same time as Norfolk Vanguard is concurrently piling, there is the potential for a moderate impact, however, as outlined above it is highly unlikely that all five offshore wind farms could be concurrently piling at exactly the same time. In addition, with the implementation of the SIP for the Southern North Sea cSAC, the potential impacts could be managed to a non-significant level, with a potential minor impact (Table 12.72).

819. The confidence that this impact assessment is precautionary enough to comfortably encompass the likely uncertainty and variability is high. Throughout the assessment it has been made clear where multiple and compounding precautionary assumptions have been taken. Additionally, where possible the uncertainty in the data typically used to inform CIAs and the quantification of impacts when based on published ESs has been removed by using a standard impact range for disturbance and the SCANS-III density estimates for all OWF sites.

Table 12.72 Cumulative impact significance for disturbance to harbour porpoise from OWF piling during piling at Norfolk Vanguard

Potential Impact	Scenario	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Cumulative impact of disturbance to harbour porpoise during single piling at OWFs at the same time as Norfolk Vanguard	Five UK and European OWF projects (including Norfolk Vanguard)	Medium	Low	Minor	SIP for SNS cSAC	**Minor adverse**
Cumulative impact of disturbance to harbour porpoise during concurrent piling at OWFs at the same time as Norfolk Vanguard	Five UK and European OWF projects (including Norfolk Vanguard)	Medium	Medium	Moderate	SIP for SNS cSAC	**Minor adverse**

12.8.4.2 Potential disturbance of grey and harbour seal during OWF piling

12.8.4.2.1 Sensitivity to disturbance

820. As outlined in section 12.7.4.2.4, grey and harbour seal are assessed as having **medium** sensitivity to disturbance from underwater noise sources (Table 12.36).

12.8.4.2.2 Magnitude of cumulative impacts

821. The magnitude of the potential disturbance of grey and harbour seal has been based on the values presented in the project ES for Tier 3 (consented) projects or in the PEIR for Tier 5 projects, where available. Where information is not available, the magnitude has been estimated based on:

- The potential impact area during single pile installation, based on a radius of 26km from piling location (2,124km^2 per project);
- The potential impact area during concurrent pile installation, based on a radius of 26km from two piling location with no overlap in impacts areas (4,248km^2 per project);
- The number of grey and harbour seal in the potential impact areas, for single and concurrent piling, has been estimated using the latest seal at sea usage maps to estimate densities (Russell *et al*., 2017) for the relevant area that the project is located.

822. Tagged harbour seals in the Wash indicated that seals were not excluded from the vicinity of the windfarm during the overall construction phase but that there was clear evidence of avoidance during pile driving, with significantly reduced levels of seal activity at ranges up to 25km from piling sites (Russell *et al*., 2016). Therefore, 26km was deemed an appropriate and precautionary potential disturbance range for both seal species.

823. The conservative potential worst-case scenario for OWFs that could be piling at the same time as Norfolk Vanguard in the southern North Sea (seal reference population area) includes four other UK OWFs as assessed for harbour porpoise (Table 12.70):

- Creyke Beck B
- Sofia
- Hornsea Project 3
- East Anglia TWO

824. In this potential worst-case scenario, for concurrent piling the estimated maximum area of potential disturbance is 21,240km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms. The maximum

number of grey seal that could potentially be disturbed is 788 (3.5% of the reference population) and 52 harbour seal (0.1% of the reference population) (Table 12.73).

825. The potential magnitude for the cumulative impacts of concurrent piling is assessed as **low** for grey seal with less than 5% of the reference population that could be temporarily distributed and **negligible** for harbour seal, with less than 1% of the reference population likely to be exposed to the effect.

826. Based on a single pile installation at each of the five OWFs, the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance between wind farms. The maximum number of grey seal that could potentially be disturbed is 593 (less than 3% of the reference population) and 26 harbour seal (0.06% of the reference population) (Table 12.73).

827. The potential magnitude for the cumulative impacts of single piling is assessed as **low** for grey seal with less than 5% of the reference population that could be temporarily distributed and **negligible** for harbour seal, with less than 1% of the reference population likely to be exposed to the effect.

Table 12.73 Quantified CIA for the potential disturbance of grey and harbour seal during single and concurrent piling of OWFs for the potential worst-case scenario based on the OWF projects which could be piling at the same time as Norfolk Vanguard.

Name of Project	Tier	Distance to NV (km)	Grey seal density estimate (No/km^2)[1]	Harbour seal density estimate (No/km^2)[1]	Potential number of grey seal disturbed		Potential number of harbour seal disturbed	
					single piling	concurrent piling	single piling	concurrent piling
Norfolk Vanguard	5	0	0.002	0.0001	4	8	0.2	0.4
Creyke Beck B	3	193	0.09	0.001	198	396	3	6
Sofia	3	175	0.09	0.001	198	396	3	6
Hornsea Project THREE	5	80	0.08	0.008	166	331	17	34
East Anglia TWO	5	45	0.01	0.002	27	53	3	6
Total					593	788	26	52
% of reference population (22,290 grey seal; 43,161 harbour seal)					**2.7%**	**3.5%**	**0.06%**	**0.1%**

[1]The densities included are based on a 26km buffer around the OWF (or grouped OWFs in the case of the Dogger Bank and East Anglia projects), using the 5x5km grid squares of the seals-at-sea total usage data that intersect with the projects and 26km buffer; based on Russell *et al*. (2017).

12.8.4.2.3 Cumulative impact significance

828. Taking into account the **medium** receptor sensitivity and the **low** potential magnitude for grey seal and **negligible** potential magnitude for harbour seal of the cumulative impacts, the overall assessment of **minor adverse** (not significant impact) for grey seal and **negligible** for harbour seal is deemed to be a conservative approach based on the assessment for the four offshore wind farms single piling or concurrent piling at the same time as Norfolk Vanguard (Table 12.74).

829. The confidence that this impact assessment is precautionary enough to comfortably encompass the likely uncertainty and variability is high.

Table 12.74 Cumulative impact significance for disturbance to grey and harbour seals from OWF piling during piling at Norfolk Vanguard

Potential Impact	Scenario	Sensitivity	Magnitude	Mitigation	Significance
Cumulative impact of disturbance to seals during single piling at OWFs at the same time as Norfolk Vanguard	Five UK and European OWF projects (including Norfolk Vanguard)	Medium	Low for grey seal Negligible for harbour seal	None proposed	**Minor adverse** for grey seal **Negligible** for harbour seal
Cumulative impact of disturbance to seals during single piling at OWFs at the same time as Norfolk Vanguard	Five UK and European OWF projects (including Norfolk Vanguard)	Medium	Low for grey seal Negligible for harbour seal	None proposed	**Minor adverse** for grey seal **Negligible** for harbour seal

12.8.5 Impact 2: Underwater noise impacts from all other noise sources

12.8.5.1 Potential disturbance of harbour porpoise from all other noise sources

830. During the construction period at Norfolk Vanguard there are other potential noise sources in addition to OWF piling that could also disturb harbour porpoise, these sources include:

- UXO clearance;
- Seismic surveys;
- OWF construction (excluding piling – see section 12.8.4);
- OWF operation and maintenance; and
- Subsea cables and pipelines.

831. The CIA screening (Appendix 12.3) determined that it was highly unlikely that the following activities could contribute significantly to the cumulative effects of the disturbance of harbour porpoise from underwater noise:

- Tidal and wave developments (construction, operation and maintenance);
- Aggregate extraction and dredging;
- Offshore mining;
- Oil and gas projects, other than potential seismic surveys;
- Licenced disposal sites;
- Navigation and shipping operations; and
- Carbon capture projects.

12.8.5.1.1 Sensitivity to disturbance

832. As outlined in section 12.7.4.2.4, harbour porpoise are assessed as having **medium** sensitivity to disturbance from underwater noise sources (Table 12.36).

12.8.5.1.2 Magnitude of cumulative impacts

UXO clearance

833. The commitment to the mitigation measures to be agreed through the MMMP for UXO clearance would result in no potential effects for lethal injury, physical injury and permanent auditory injury (PTS). As such, the proposed Norfolk Vanguard project would not contribute to any cumulative impacts for lethal injury, physical injury and permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

834. It is currently not possible to estimate the number of potential UXO clearance operations that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Vanguard.

835. It is therefore assumed as a worst-case scenario that there could potentially be:

- Up to one UXO clearance operation in the UK northern North Sea area;
- Up to one UXO clearance operation in the UK southern North Sea area;
- Up to one UXO clearance operation in the Netherlands / Belgium area of the North Sea; and
- Up to one UXO clearance operation in the German / Denmark area of the North Sea.

836. Following the current SNCB advice, the CIA has been based on the following parameter:

- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise could potentially be disturbed.

837. Therefore, for the maximum of up to four UXO clearance events being undertaken at the same time the potential disturbance area would be 8,496km^2.

838. The SCANS-III harbour porpoise density estimate for the North Sea MU is 0.52/km^2 (Hammond *et al*., 2017). Without knowing the actual location for any UXO clearance this has been used to estimate the potential number of harbour porpoise that could potentially be disturbed (Table 12.75).

839. The number of harbour porpoise that could potentially be disturbed during one UXO clearance operation would be up to 1,105 harbour porpoise (0.3% of the NS MU reference population).

840. The maximum number of harbour porpoise that could potentially be disturbed during up to four UXO clearance operations would be up to 4,420 harbour porpoise, which represents up to 1% of the NS MU reference population (Table 12.75). The potential magnitude of the temporary effect is assessed as low, with between 1% and 5% of the reference population likely to be exposed to the effect.

841. However, it is highly unlikely that up to four UXO clearance operations would actually be undertaken at the same time, therefore a more likely worst-case scenario would be for two UXO operations (4,248km^2) in the southern North Sea, which could potentially be disturbed up to 2,210 harbour porpoise (approximately 0.6% of the North Sea MU reference population). Therefore, the magnitude would be **negligible**, with less than 1% of reference population likely to be disturbed, based on the more realistic worst-case scenario of up to two UXO operations being undertaken at the same time.

Table 12.75 Quantified CIA for the potential disturbance of harbour porpoise during UXO clearance operations in the North Sea during construction at Norfolk Vanguard.

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise impacted
Up to one UXO clearance operation in the UK northern North Sea area	0.52	2,124km^2	1,105
Up to one UXO clearance operation in the UK northern North Sea area	0.52	2,124km^2	1,105
Up to one UXO clearance operation in the Netherlands / Belgium area of the North Sea	0.52	2,124km^2	1,105
Up to one UXO clearance operation in the German / Denmark area of the North Sea	0.52	2,124km^2	1,105
Total for 4 UXO (% of NS MU reference population (345,373 harbour porpoise))		**8,496km^2**	**4,420 (1%)**

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise impacted
Total for 2 UXO (% of NS MU reference population (345,373 harbour porpoise))		**4,248km^2**	**2,210 (0.6%)**

Seismic surveys

842. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Vanguard.

843. It is therefore assumed as a worst-case scenario that there could potentially be:

- Up to one seismic survey in the UK northern North Sea area;
- Up to one seismic survey in the UK southern North Sea area;
- Up to one seismic survey in the Netherlands / Belgium area of the North Sea; and
- Up to one seismic survey in the German / Denmark area of the North Sea.

844. Following the current SNCB advice, the CIA has been based on the following parameter:

- A distance of 10km around seismic surveys has been used to assess the area that harbour porpoise could potentially be disturbed (314km^2).

845. It should be noted that this assessment is based on the potential impacts for seismic surveys required by the oil and gas industry. Geophysical surveys conducted for offshore wind farms generally use multi-beam surveys in shallow waters. The higher frequencies typically used for surveys for offshore wind farms fall outside the hearing frequencies of cetaceans and the sounds produced are likely to attenuate more quickly than the lower frequencies used in deeper waters (JNCC, 2017e). JNCC (2071e) do not, therefore, advise mitigation is required for multi-beam surveys in shallow waters as there is no risk to EPS in relation to deliberate injury or disturbance offences.

846. Therefore, for the maximum of up to four seismic surveys being undertaken at the same time the potential disturbance area would be 1,256km^2.

847. The SCANS-III harbour porpoise density estimate for the North Sea MU is 0.52/km^2 (Hammond *et al*., 2017). Without know the actual location for any seismic survey this has been used to estimate the potential number of harbour porpoise that could potentially be disturbed (Table 12.76).

848. The number of harbour porpoise that could potentially be disturbed during one seismic survey would be up to 163 harbour porpoise (0.05% of the NS MU reference population).

849. The maximum number of harbour porpoise that could potentially be disturbed during up to four seismic surveys would be up to 652 harbour porpoise, which represents up to 0.2% of the NS MU reference population (Table 12.76). The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

850. However, it is highly unlikely that up to four seismic surveys would be undertaken at the same time; therefore, a more likely worst-case scenario would be for two seismic surveys (628km^2) in the southern North Sea, which could potentially disturb up to 326 harbour porpoise (approximately 0.09% of the North Sea MU reference population). Therefore, the magnitude would be **negligible**, with less than 1% of reference population likely to be disturbed.

Table 12.76 Quantified CIA for the potential disturbance of harbour porpoise during seismic surveys in the North Sea during construction at Norfolk Vanguard.

Seismic surveys	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise impacted
Up to one seismic survey in the UK northern North Sea area	0.52	314km^2	163
Up to one seismic survey in the UK northern North Sea area	0.52	314km^2	163
Up to one seismic survey in the Netherlands / Belgium area of the North Sea	0.52	314km^2	163
Up to one seismic survey in the German / Denmark area of the North Sea	0.52	314km^2	163
Total for 4 seismic surveys (% of NS MU reference population (345,373 harbour porpoise))		**1,256km^2**	**652 (0.2%)**
Total for 2 seismic surveys (% of NS MU reference population (345,373 harbour porpoise))		**628km^2**	**326 (1.5%)**

OWF construction

851. During the construction of Norfolk Vanguard there is the potential to overlap with impacts from the construction activities, other than piling, at other offshore wind farms. Noise sources which could cause potential disturbance impacts during OWF construction activities, other than pile driving, can include vessels, seabed preparation, ploughing / jetting / pre-trenching or cutting for installation of cables and rock dumping for protection of the cable.

852. There would be no additional cumulative impacts of underwater noise from other construction activities for those projects which also have overlapping piling with

Norfolk Vanguard as the ranges for piling would be significantly greater than those from other construction noise sources.

853. The potential impact ranges of these noise sources during OWF construction will be localised and significantly less than the ranges predicted for piling. There could be potential cumulative impacts from construction of OWFs in and around the area of Norfolk Vanguard.

854. The CIA determined the UK and European OWFs in the southern North Sea which could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period. This precautionary realistic worst-case scenario, included six UK OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period:

- Creyke Beck A
- Teesside A
- East Anglia THREE
- East Anglia ONE North
- Thanet Extension; and
- Norfolk Boreas

855. The potential temporary disturbance during OWF construction activities, other than pile driving noise sources, has been based on the area of the OWF sites. This is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place.

856. In addition, it is likely, as outlined for the cumulative impact assessment for piling, that developers of more than one site will develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site.

857. For each project, the number of harbour porpoise in the area of each OWF site has been estimated using the latest SCANS-III density estimates (Hammond *et al*., 2017) for the relevant survey block that the project is located within. The number of harbour porpoise that could potentially be disturbed has been put into the context of the reference population for the North Sea MU.

858. Based on this highly conservative approach, an assessment has been undertaken for the six UK OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period.

859. The assessment indicates that if all six of these OWFs in the southern North Sea were conducting construction activities, other than piling, at the same time, the estimated maximum cumulative area of disturbance is 2,384km^2 and the maximum number of harbour porpoise that could potentially be disturbed is 1,925 individuals, which represents approximately 0.6% of the North Sea MU reference population (Table 12.77). Therefore, the potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

Table 12.77 Quantified CIA for the potential disturbance of harbour porpoise during construction activities (other than piling) at UK and European OWFs during construction at Norfolk Vanguard.

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Creyke Beck A	163	O	0.888	515km^2	457
Teesside A	180	N	0.837	562km^2	470
East Anglia THREE	0	L	0.607	301km^2	183
Norfolk Boreas[1]	30	O	0.888	727km^2	646
Thanet Extension	165	L	0.607	73km^2	44
East Anglia ONE North	30	L	0.607	206km^2	125
Total				**2,384km^2**	**1,925**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.6%**

*Source: http://www.4coffshore.com/
[1]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore, higher density estimate from survey block O is used.

OWF operation and maintenance

860. There is the potential for disturbance from other OWFs that have already been constructed as a result of any operational and maintenance activities, including vessels, during the Norfolk Vanguard construction period. The potential disturbance from operational OWFs and maintenance activities could include the operational turbines, vessels, any rock dumping or cable re-burial.

861. As outlined in section 12.7.5.2 and section 12.7.5.3, any potential disturbance as a result of underwater noise from these activities will be temporary and limited to the area of the OWF sites, although this is a precautionary approach, as it is highly unlikely that operational OWFs and maintenance activities, including vessels, would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place. There is currently no evidence of any significant disturbance of harbour porpoise from operational wind farm sites.

862. Operational UK and European OWFs in the southern North Sea that could have potential cumulative impacts during the Norfolk Vanguard construction period have an estimated maximum potential cumulative area up to 2,185km^2 and the maximum number of harbour porpoise that could be temporarily disturbed would be up to 1,457 individuals which represents approximately 0.4% of the North Sea MU reference population (Table 12.78). Therefore, the potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

Table 12.78 Quantified CIA for the potential disturbance of harbour porpoise during operation and maintenance activities at UK OWFs during construction at Norfolk Vanguard

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Greater Gabbard	96	L	0.607	146	89
Gunfleet Sands 3 (Demo Zone)	148	L	0.607	3	2
Gunfleet Sands I	143	L	0.607	16	10
Humber Gateway	156	O	0.888	27	24
Inner Dowsing	127	O	0.888	10	9
Kentish Flats	174	L	0.607	10	6
Kentish Flats Extension	175	L	0.607	8	5
Lincs	122	O	0.888	41	36
London Array	138	L	0.607	122	74
Lynn	127	O	0.888	10	9
Scroby Sands	45	L	0.607	4	2
Sheringham Shoal	75	O	0.888	35	31
Teesside	292	O	0.888	4	4
Thanet	159	L	0.607	35	21
Westermost Rough	169	O	0.888	35	31
Dudgeon	66	O	0.888	55	49
Galloper	93	L	0.607	113	69
Hornsea Project One	95	O	0.888	407	361
Race Bank	94	O	0.888	62	55
East Anglia ONE	40	L	0.607	205	124
Belwind	116	N	0.837	13	11
Belwind Alstom Haliade Demonstration	118	N	0.837	1	1

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Nobelwind	1168	N	0.837	22	18
Northwind	124	L	0.607	14	8
Thornton Bank phase I	134	N	0.837	2	2
Thornton Bank phase II	131	N	0.837	12	10
Thornton Bank phase III	133	N	0.837	7	6
Haliade	633	P	0.823	1	1
Horns Rev 1	419	M	0.277	21	6
Horns Rev 2	414	M	0.277	33	9
Rønland	531	P	0.823	10	8
Nissum Bredning Vind	555	P	0.823	5	4
Vesterhav Nord/Syd	560	P	0.823	10	8
Alpha Ventus	263	N	0.837	4	3
Amrumbank West	349	M	0.277	33	9
BARD Offshore 1	244	N	0.837	59	49
Borkum Riffgrund I	255	N	0.837	36	30
Butendiek (Offshore- Bürger-windpark)	384	M	0.277	33	9
Dan Tysk	360	M	0.277	66	18
ENVA Ems Emden	270	M[1]	0.277	1	0
Global Tech I	277	M	0.277	42	12
Gode Wind 1 and 2	283	M	0.277	70	19
Meerwind Ost Sud	341	M	0.277	40	11
Nordsee Ost	344	M	0.277	36	10
Riffgat	240	N	0.837	6	5
Sandbank	347	M	0.277	47	13

Name of Project	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of harbour porpoise disturbed
Trianel Windpark Borkum Phase 1 (Borkum West II phase 1)	254	M	0.277	23	6
Veja Mate	236	N	0.837	51	43
Egmond aan Zee (aka OWEZ)	88	N	0.837	24	20
Eneco Luchterduinen	84	N	0.837	16	13
Gemini	221	N	0.837	70	59
Irene Vorrink	168	N[1]	0.837	2	2
Prinses Amalia Windpark (formerly Q7)	79	N	0.837	17	14
Westermeerwind	168	N[1]	0.837	8	7
Hywind - Metcentre	696	V	0.137	2	0
Total				**2,185km^2**	**1,457**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.4%**

*Source: http://www.4coffshore.com/
[1]closest block, but is not actually within the SCANS-III area

Subsea cables and pipelines

863. Subsea cables and pipelines only have the potential for cumulative impacts with Norfolk Vanguard during their installation. The CIA screening (Appendix 12.3) identified ten Tier 2 and five Tier 4 and 5 projects in the MU for harbour porpoise. The underwater noise that could be generated during the seabed preparation, ploughing / jetting / pre-trenching or cutting for installation of cables / pipelines, rock dumping for protection of the cable / pipelines, and installation vessels, would be restricted to the area of installation.

864. There is a high level of existing noise in the area, to which marine mammals appear to have acclimatised, and the ranges of potential disturbance from vessels and other sources would be localised and temporary. The magnitude of effect is therefore, considered to be **low**.

Overall magnitude of cumulative impacts from noise sources (other than piling)

865. The potential cumulative impacts from noise sources (other than piling) at Norfolk Vanguard and other OWFs that could be constructing at the same time as Norfolk Vanguard is summarised in Table 12.79. This assessment is based on highly conservative assumptions (e.g. displacement of all harbour porpoise from the boundary of each offshore wind farm and the assumption that there is no overlap from the disturbance impacts listed).

866. The maximum number of harbour porpoise that could potentially be temporarily disturbed as a result of underwater noise from all other potential noise sources and activities, other than OWF piling, during construction, including piling at Norfolk Vanguard is 5,918 individuals, which represents approximately 2% of the North Sea MU reference population (Table 12.79).

867. The potential magnitude of the temporary effect is assessed as **low**, with between 1% and 5% of the reference population likely to be exposed to the effect.

Table 12.79 Quantified CIA for the potential disturbance of harbour porpoise from all possible noise sources (other the OWF piling) during piling at Norfolk Vanguard

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of harbour porpoise disturbed
UXO clearance (up to 2 operations)	4,248km^2	2,210
Seismic surveys (up to 2 surveys)	628km^2	326
UK and European OWF construction activities in the southern North Sea (i.e. OWFs that are not piling but potential construction activities)	2,384km^2	1,925
Operation and maintenance of UK and European OWFs in southern	2,185km^2	1,457

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of harbour porpoise disturbed
North Sea		
Total for other noise sources (excluding piling)	**9,445m²**	**5,918**
% of NS MU reference population (345,373 harbour porpoise)		**2%**

12.8.5.1.3 Cumulative impact significance

868. Table 12.80 summarises the potential cumulative impact significance for disturbance to harbour porpoise from other noise sources during Norfolk Vanguard construction and piling. Based on medium sensitivity and low magnitude of effect resulting from cumulative noise sources, the impact significance would be **minor adverse** (not significant).

Table 12.80 Cumulative impact significance for disturbance to harbour porpoise from other noise sources during Norfolk Vanguard piling

Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
All possible noise sources including piling	Medium	Low	Minor	None proposed	**Minor adverse**

12.8.5.2 Potential disturbance of grey and harbour seal from all other noise sources

869. During the construction period at Norfolk Vanguard there are other potential noise sources in addition to OWF piling that could also disturb grey and harbour seal, these sources include:

- UXO clearance;
- Seismic surveys;
- OWF construction (excluding piling – see section 12.8.4);
- OWF operation and maintenance; and
- Subsea cables and pipelines.

870. The CIA screening (Appendix 12.3) determined that it was highly unlikely that the following activities could contribute significantly to the cumulative effects of disturbance from underwater noise:

- Tidal and wave developments (construction, operation and maintenance);
- Aggregate extraction and dredging;

- Offshore mining;
- Oil and gas projects, other than potential seismic surveys;
- Licenced disposal sites;
- Navigation and shipping operations; and
- Carbon capture projects.

12.8.5.2.1 Sensitivity to disturbance

871. As outlined in section 12.7.4.2.4, grey and harbour seal are assessed as having **medium** sensitivity to disturbance from underwater noise sources (Table 12.36).

12.8.5.2.2 Magnitude of cumulative impacts

UXO clearance

872. It is currently not possible to estimate the number of potential UXO clearance operations that could be undertaken in the grey and harbour seal MUs during the construction and potential piling activity at Norfolk Vanguard.

873. It is therefore assumed as a worst-case scenario that there could potentially be up to four UXO clearance (section 12.8.5.1.2).

874. Based on a distance of 26km around each UXO clearance, the maximum potential disturbance area would be 8,496km^2 for four UXO clearance events being undertaken at the same time in the North Sea.

875. Without knowing the actual location for any UXO clearance the mean density estimates are based on the average seal at sea density estimates for the areas of the UK and EU OWFs. This is 0.1 grey seal per km^2 and 0.02 harbour seal per km^2. This is based on the seal-at-sea maps (Russell *et al.*, 2017) and an average density based on a 50km buffer around all OWFs (UK and EU) included within the CIA.

876. The number of grey seal that could potentially be disturbed during one UXO clearance operation (2,124km^2) would be up to 212 individuals (0.95% of the reference population). The number of harbour seal that could potentially be disturbed during one UXO clearance operation would be up to 43 individuals (0.1% of the reference population).

877. The maximum number of grey seal that could potentially be disturbed during up to four UXO clearance operations (8,496km^2) would be up to 850 individuals, which represents up to 4% of the reference population. The potential magnitude of the temporary effect is assessed as low, with between 1% and 5% of the reference population likely to be exposed to the effect.

878. The maximum number of harbour seal that could potentially be disturbed during up to four UXO clearance operations (8,496km^2) would be up to 170 individuals, which represents up to 0.4% of the reference population. The potential magnitude of the temporary effect is assessed as negligible, with less than 1% of the reference population likely to be exposed to the effect.

879. However, it is highly unlikely that up to four UXO clearance operations would actually be undertaken at the same time, therefore a more likely worst-case scenario would be for two UXO operations (4,248km^2), which could potentially disturb up to 425 grey seal (2% of the reference population). Therefore, the magnitude would be **low**, with between 1% and 5% of reference population likely to be disturbed. The maximum number of harbour seal that could potentially be disturbed would be 85 (0.2% of the reference population). The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

Seismic surveys

880. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the grey and harbour seal MUs during the construction and potential piling activity at Norfolk Vanguard.

881. It has therefore been assumed as a worst-case scenario that there could potentially be up to four seismic surveys (section 12.8.5.1.2).

882. Based on a distance of 10km (314km^2) around each seismic survey, the maximum potential disturbance area would be 1,256km^2 for four seismic surveys being undertaken at the same time.

883. Without knowing the actual location for any seismic surveys, the mean density estimates have been based on the average seal at sea density estimates for the areas of the UK and EU OWFs. As outlined above, this is 0.1 grey seal per km^2 and 0.02 harbour seal per km^2.

884. The number of grey seal that could potentially be disturbed during one seismic survey would be up to 31 individuals (0.1% of the reference population). The number of harbour seal that could potentially be disturbed during one seismic survey would be up to 6 individuals (0.01% of the reference population).

885. The maximum number of grey seal that could potentially be disturbed during up to four seismic surveys would be up to 126 individuals, which represents up to 0.6% of the reference population. The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

886. The maximum number of harbour seal that could potentially be disturbed during up to four seismic surveys would be up to 25 individuals, which represents up to 0.06% of the reference population. The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

887. However, it is highly unlikely that up to four seismic surveys would be undertaken at the same time; therefore, a more likely worst-case scenario would be for two seismic surveys (628km^2), which could potentially disturb up to 63 grey seal (0.3% of the reference population). Therefore, the magnitude would be **negligible**, with less than 1% of the reference population likely to be disturbed. The maximum number of harbour seal that could potentially be disturbed would be 13 (0.03% of the reference population). The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

OWF construction

888. During the construction of Norfolk Vanguard there is the potential to overlap with impacts from the construction activities, other than piling, of offshore wind farms. Noise sources which could cause potential disturbance impacts during OWF construction activities, other than pile driving, can include vessels, seabed preparation, ploughing / jetting / pre-trenching or cutting for installation of cables and rock dumping for protection of the cable.

889. The potential impact ranges of these noise sources during OWF construction will be localised and significantly less than the ranges predicted for piling. There could be potential cumulative impacts from construction of OWFs in and around the area of Norfolk Vanguard. As a precautionary approach the CIA includes UK and European OWFs in the southern North Sea which could potentially be constructing at the same time as Norfolk Vanguard.

890. This highly conservative approach for OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period includes six UK OWFs:

- Creyke Beck A
- Teesside A
- East Anglia THREE
- East Anglia ONE North
- Thanet Extension; and
- Norfolk Boreas

891. The potential temporary disturbance during OWF construction activities, other than pile driving noise sources, has been based on the area of the OWF sites. This is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place.

892. The assessment indicates that if all six of these OWFs in the southern North Sea were conducting construction activities, other than piling, at the same time, the estimated maximum cumulative area of disturbance is 2,384km^2 and the maximum number of grey seal that could potentially be disturbed is 33 individuals, which represents approximately 0.15% of the reference population (Table 12.81). The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

893. The maximum number of harbour seal that could potentially be disturbed is 5 individuals, which represents approximately 0.01% of the reference population (Table 12.81). The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

Table 12.81 Quantified CIA for the potential disturbance of grey and harbour seal during construction activities (other than piling) at UK and European OWFs during construction at Norfolk Vanguard.

Name of Project	Country	Distance to NV (km)	Grey seal density estimate (No/km^2)	Harbour seal density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of grey seal impacted	Potential number of harbour seal impacted
Creyke Beck A	UK	163	0.05	0.0004	515	26	0.2
Teesside A	UK	180	0.01	0.00004	562	6	0.02
East Anglia THREE	UK	0	0.00009	0.00009	301	0.03	0.03
Thanet Extension	UK	165	0.02	0.06	73	1	4.4
East Anglia ONE North	UK	30	0.0009	0.0006	206	0.2	0.1
Norfolk Boreas	UK	30	0.0006	0.00006	727	0.4	0.04
Total					**2,384**	**33**	**5**
% of reference population (22,290 grey seal; 43,161 harbour seal)						**0.15%**	**0.01%**

*Source: http://www.4coffshore.com/

OWF operation and maintenance

894. The potential disturbance from operational OWFs and maintenance activities could include the operational turbines, vessels, any rock dumping or cable re-burial.

895. As outlined in section 12.7.5.2 and section 12.7.5.3, any potential disturbance as a result of underwater noise from these activities will be temporary and limited to the area of the OWF sites, although this is a precautionary approach, as it is highly unlikely that operational OWFs and maintenance activities, including vessels, would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place. There is currently no evidence of any significant disturbance of seals from operational wind farm sites.

896. Operational UK and European OWFs in the southern North Sea that could have potential cumulative impacts during the Norfolk Vanguard construction period have an estimated maximum potential cumulative area up to 2,185km^2 and the maximum number of grey seal that could potentially be disturbed is 257 individuals, which represents approximately 1% of the reference population (Table 12.82). The potential magnitude of the temporary effect is assessed as **low**, with between 1% and 5% of the reference population likely to be exposed to the effect.

897. The maximum number of harbour seal that could potentially be disturbed is 80 individuals, which represents approximately 0.2% of the reference population (Table 12.82). The potential magnitude of the temporary effect is assessed as **negligible**, with less than 1% of the reference population likely to be exposed to the effect.

Table 12.82 Quantified CIA for the potential disturbance of grey and harbour seal during operation and maintenance activities at UK OWFs during construction at Norfolk Vanguard.

Name of Project	Distance to NV (km)	Grey seal density estimate (No/km^2)	Harbour seal density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of grey seal impacted	Potential number of harbour seal impacted
Greater Gabbard	96	0.01	0.002	146	1.46	0.292
Gunfleet Sands 3 (Demo Zone)	148	0.09	0.04	3	0.27	0.12
Gunfleet Sands I	143	0.09	0.04	16	1.44	0.64
Humber Gateway	156	1.53	0.01	27	41.31	0.27
Inner Dowsing	127	0.31	0.31	10	3.1	3.1
Kentish Flats	174	0.05	0.09	10	0.5	0.9
Kentish Flats Extension	175	0.05	0.09	8	0.4	0.72
Lincs	122	0.31	0.31	41	12.71	12.71
London Array	138	0.08	0.02	122	9.76	2.44
Lynn	127	0.31	0.31	10	3.1	3.1
Scroby Sands	45	0.56	0.08	4	2.24	0.32
Sheringham Shoal	75	0.17	0.16	35	5.95	5.6
Teesside	292	0.001	0.02	4	0.004	0.08
Thanet	159	0.02	0.05	35	0.7	1.75
Westermost Rough	169	0.11	0.02	35	3.85	0.7
Dudgeon	66	0.11	0.19	55	6.05	10.45
Galloper	93	0.01	0.001	113	1.13	0.113
Hornsea Project One	95	0.39	0.05	407	158.73	20.35
Race Bank	94	0.07	0.26	62	4.34	16.12
East Anglia ONE	40	0.001	0.0003	205	0.205	0.0615
Belwind	116.43	0.0003	0.0002	13	0.0039	0.0026

Name of Project	Distance to NV (km)	Grey seal density estimate (No/km^2)	Harbour seal density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of grey seal impacted	Potential number of harbour seal impacted
Belwind Alstom Haliade Demonstration	118.25	0.0003	0.0002	1	0.0003	0.0002
Nobelwind	115.78	0.0003	0.0002	22	0.0066	0.0044
Northwind	123.6	0.0003	0.0002	14	0.0042	0.0028
Thornton Bank phase I	134.05	0.0002	0.0001	2	0.0004	0.0002
Thornton Bank phase II	131.32	0.0002	0.0001	12	0.0024	0.0012
Thornton Bank phase III	133.29	0.0002	0.0001	7	0.0014	0.0007
Haliade	633	0.00002	0.00004	1	0.00002	0.00004
Horns Rev 1	419.07	0.000002	0.00004	21	0.000042	0.00084
Horns Rev 2	413.48	0.000002	0.00004	33	0.000066	0.00132
Rønland	531	0.000002	0.00004	10	0.00002	0.0004
Nissum Bredning Vind	555	0.000002	0.00004	5	0.00001	0.0002
Vesterhav Nord/Syd	560	0.000002	0.00004	10	0.00002	0.0004
Alpha Ventus	262.75	0.000002	0.00004	4	0.000008	0.00016
Amrumbank West	349.12	0.000002	0.00004	33	0.000066	0.00132
BARD Offshore 1	244.05	0.000003	0.00004	59	0.000177	0.00236
Borkum Riffgrund I	255.4	0.000003	0.00004	36	0.000108	0.00144
Butendiek (Offshore- Bürger- windpark)	384	0.00002	0.00004	33	0.00066	0.00132
Dan Tysk	359.55	0.000002	0.00004	66	0.000132	0.00264
ENVA Ems Emden	270.2	0.000002	0.00004	1	0.000002	0.00004
Global Tech I	276.81	0.000002	0.00004	42	0.000084	0.00168
Gode Wind 1 and 2	283.15	0.000002	0.00004	70	0.00014	0.0028
Meerwind Ost Sud	341.15	0.000002	0.00004	40	0.00008	0.0016
Nordsee Ost	343.75	0.000002	0.00004	36	0.000072	0.00144

Name of Project	Distance to NV (km)	Grey seal density estimate (No/km^2)	Harbour seal density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of grey seal impacted	Potential number of harbour seal impacted
Riffgat	239.73	0.000003	0.00004	6	0.000018	0.00024
Sandbank	346.8	0.000002	0.00004	47	0.000094	0.00188
Trianel Windpark Borkum Phase 1 (Borkum West II phase 1)	254.16	0.000003	0.00004	23	0.000069	0.00092
Veja Mate	236.49	0.000003	0.00004	51	0.000153	0.00204
Egmond aan Zee (aka OWEZ)	88.07	0.00005	0.00004	24	0.0012	0.00096
Eneco Luchterduinen	84.51	0.0001	0.00005	16	0.0016	0.0008
Gemini	221.37	0.000004	0.00004	70	0.00028	0.0028
Irene Vorrink	168.35	0.00001	0.00004	2	0.00002	0.00008
Prinses Amalia Windpark (formerly Q7)	78.8	0.00004	0.00001	17	0.00068	0.00017
Westermeerwind	167.79	0.00002	0.00004	8	0.00016	0.00032
Hywind - Metcentre	696	0.001	0.00004	2	0.002	0.00008
Total				**2,185km^2**	**257**	**80**
% of reference population (22,290 grey seal; 43,161 harbour seal)					**1%**	**0.2%**

*Source: http://www.4coffshore.com/

Subsea cables and pipelines

898. Subsea cables and pipelines only have the potential for cumulative impacts with Norfolk Vanguard during their installation. The CIA screening (Appendix 12.3) identified ten Tier 2 and five Tier 4 and 5 projects in the MU for harbour porpoise. The underwater noise that could be generated during the seabed preparation, ploughing / jetting / pre-trenching or cutting for installation of cables / pipelines, rock dumping for protection of the cable / pipelines, and installation vessels, would be restricted to the area of installation.

899. There is a high level of existing noise in the area, to which marine mammals appear to have acclimatised, and the ranges of potential disturbance from vessels and other sources would be localised and temporary. The magnitude of effect is therefore, considered to be **low**.

Overall magnitude of cumulative impacts from noise sources (other than piling)

900. The potential cumulative impacts from noise sources (other than piling) at Norfolk Vanguard and other OWFs that could be occurring at the same time as Norfolk Vanguard is summarised in Table 12.83. This assessment is based on highly conservative assumptions (e.g. displacement of all seals from the boundary of each offshore wind farm and the assumption that there is no overlap from the disturbance impacts listed).

901. The potential magnitude of the temporary effect is assessed as **low** for grey seal, with less than 5% of the reference population likely to be exposed to the effect and **negligible** for harbour seal, with less than 1% of the reference population likely to be exposed to the effect.

Table 12.83 Quantified CIA for the potential disturbance of grey seal and harbour seal from all possible noise sources (other than OWF piling) during piling at Norfolk Vanguard

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of grey seal impacted	Potential number of harbour seal impacted
UXO clearance (up to 2 operations)	4,248km^2	425	85
Seismic surveys (up to 2 surveys)	628km^2	63	13
UK and European OWF construction activities (i.e. OWFs that are not piling but potential construction activities)	2,384km^2	33	5
Operation and maintenance of UK and European OWFs	2,185km^2	257	80

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of grey seal impacted	Potential number of harbour seal impacted
Total	**9,445km²**	**778**	**183**
% of reference population (22,290 grey seal; 43,161 harbour seal)		**3.5%**	**0.4%**

12.8.5.2.3 Cumulative impact significance

902. Table 12.84 summarises the potential cumulative impact significance for disturbance to grey seal from other noise sources during Norfolk Vanguard construction and piling. Based on **medium** sensitivity and **low** magnitude of effect resulting from cumulative noise sources excluding piling, the impact significance is assessed as **minor** (not significant). The overall magnitude for harbour seal is **negligible**, resulting in a **minor** significance.

Table 12.84 Cumulative impact significance for disturbance to harbour seal and grey seal from other noise sources during Norfolk Vanguard piling

Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
All possible noise sources during piling at Norfolk Vanguard	Medium	Low for grey seal Low for harbour seal	Minor for grey seal Minor for harbour seals	None proposed.	**Minor adverse**

12.8.6 Summary of the cumulative underwater noise impacts (Impacts 1 and 2)

12.8.6.1 Magnitude of cumulative impacts

903. This section considers the overall cumulative impact of underwater noise associated with piling (impact 1) and other noise sources (impact 2). There would be no additional cumulative impacts of noise from other construction activities for those projects which also have overlapping piling with Norfolk Vanguard as the impact ranges for piling would be significantly greater than those impacts from other construction noise sources.

904. The potential cumulative impacts from all noise sources at Norfolk Vanguard and other OWFs that could be occurring at the same time as Norfolk Vanguard construction are summarised in Table 12.85.

905. The potential magnitude of the temporary effect is assessed as **low** for harbour porpoise, with less than 5% of the reference population estimated to be disturbed, **medium** for grey seal, with between 5% and 10% of the reference population potentially exposed to the effect and negligible for harbour seal, with less than 1% of the reference population likely to be exposed to the effect.

906. This assessment is based on highly conservative assumptions (e.g. displacement of all marine mammals from the boundary of each offshore wind farm and the assumption that there is no overlap from the disturbance impacts listed).

Table 12.85 Quantified CIA for the potential disturbance of marine mammals from all possible noise sources during piling at Norfolk Vanguard

Potential noise sources during Norfolk Vanguard piling	Area of potential disturbance	Potential number of harbour porpoise impacted	Potential number of grey seal impacted	Potential number of harbour seal impacted
UK and European OWF projects, including Norfolk Vanguard, with the potential of single piling at the same time (see Impact 1)	10,620km^2	8,833	593	26
UXO clearance (up to 2 operations)	4,248km^2	2,210	425	85
Seismic surveys (up to 2 surveys)	628km^2	326	63	13
UK and European OWF construction activities (i.e. OWFs that are not piling but potential construction activities)	2,384km^2	1,925	33	5
Operation and maintenance of UK and European OWFs	2,185km^2	1,495	257	80
Total		**14,789**	**1,371**	**209**
% of reference population (345,373 harbour porpoise; 22,290 grey seal; 43,161 harbour seal)		**4%**	**6%**	**0.5%**

12.8.6.2 Cumulative impact significance

907. Based on **medium** sensitivity and **low** magnitude of effect resulting from cumulative noise sources, the impact significance is assessed as **minor** for harbour porpoise. Based on **medium** sensitivity and **medium** magnitude of effect resulting from cumulative noise sources, the impact significance is assessed as **moderate** for grey seal. The overall magnitude for harbour seal is **negligible**, resulting in a **minor** significance.

Mitigation

908. The Norfolk Vanguard contribution to the overall cumulative impact from underwater noise (Table 12.85), during single pile installation, would potentially be the disturbance of up to 1,886 harbour porpoise, approximately 11% of the total 17,324 harbour porpoise that could be disturbed; the disturbance of up to four grey seal, approximately 0.2% of the total of 2,166 grey seal that could be disturbed; and the disturbance of less than one harbour seal (0.2 harbour seal), approximately 0.05% of the 410 harbour seal that could be disturbed.

909. The Site Integrity Plan, to reduce the potential disturbance at the project level and in particular in relation to the Southern North Sea cSAC, would be agreed with the relevant SNCBs post-consent. In order to address the overall cumulative impact, a possible strategic approach to mitigation could be required which Norfolk Vanguard Limited is open to discussing with Natural England and the Marine Management Organisation. An outline Site Integrity Plan (document 8.17) is submitted with the Norfolk Vanguard DCO application.

Residual impact

910. It is anticipated that by working with the relevant SNCBs and the Marine Management Organisation to develop mitigation measures and a possible strategic approach, the potential cumulative impacts of construction noise, including piling, could ensure a minor **adverse** (not significant) impact on the harbour porpoise or grey seal.

Table 12.86 Cumulative impact significance for disturbance to harbour porpoise, grey seal and harbour seal from all potential noise sources during Norfolk Vanguard piling

Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
All possible noise sources during piling at Norfolk Vanguard	Medium	Low for harbour porpoise Medium for grey seal Negligible for harbour seal	Minor for harbour porpoise Moderate for grey seal Minor for harbour seals	Possible strategic approach to reduce the magnitude of the cumulative impacts, if required.	**Minor adverse**

12.8.7 Impact 3: Indirect impacts – changes in prey availability

911. Potential impacts on prey species during construction can result from increased suspended sediment concentrations and sediment re-deposition and underwater noise (leading to mortality, physical injury, auditory injury or behavioural responses); the potential impacts on fish species during operation and maintenance are physical disturbance and loss or changes of seabed habitat, introduction of hard substrate, operational noise, and EMF; and during decommissioning potential impacts on fish species include physical disturbance, loss or changes of habitat, increased suspended sediment concentrations, re-mobilisation of contaminated sediments and underwater noise. Some of the impacts could be negative with fish species moving away or being lost from an area, some impacts could have a negative or positive effect, such as possible changes in species composition, and other impacts could result in a positive effect, such as the aggregation of prey around seabed structures.

912. The potential effects on marine mammals of any changes to prey availability can include changes in distribution, abundance and community structure, increased competition with other marine mammal species, increased susceptibility to disease and contaminants, and implications for reproductive success, which could potentially impact individuals throughout their range or at different times of the year. However, any changes to prey tend to be localised and temporary in nature. In addition, if prey species are disturbed from an area, it is highly likely that marine mammals will also be disturbed from the area over a potentially wider range than prey species.

913. The cumulative assessment on potential changes to prey availability has assumed that any potential impacts on marine mammal prey species from underwater noise, including piling, would be the same or less than those for marine mammals. Therefore, there would be no additional impacts other than those assessed for marine mammals, i.e. if prey are disturbed from an area as a result of underwater noise, marine mammals will be disturbed from the same or greater area, therefore any changes to prey availability would not affect marine mammals as they would already be disturbed from the same area.

914. Any impacts on prey species are likely to be intermittent, temporary and highly localised, with potential for recovery following cessation of the disturbance activity. Any permanent loss or changes of prey habitat will typically represent a small percentage of the potential habitat in the surrounding area. However, there is the potential for long term duration; therefore, the magnitude for all marine mammal species is considered to be **low**, rather than negligible.

12.8.7.1.1 Cumulative impact significance

915. Grey seal and harbour seal are considered to have low sensitivity to changes in prey resources and harbour porpoise are considered to have 'low to medium' sensitivity to changes in prey resources (see section 12.7.4.8.1).

916. Based on the sensitivity of harbour porpoise, grey seal and harbour seal and the potential magnitude of effect, the cumulative impact of any changes to prey availability is assessed as having the potential to be **negligible** to **minor adverse** for the three species (Table 12.87).

Table 12.87 Cumulative assessment of impact significance of changes in prey availability on marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Changes to prey availability	Harbour porpoise	Low to Medium	Low	Minor	No further mitigation currently required, beyond embedded mitigation to reduce piling noise impacts.	**Minor**
	Grey seal	Low	Medium	Minor		**Minor**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

12.8.8 Impact 4: Direct interaction - collision risk

917. During the construction and decommissioning of OWFs vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is within the wind farm site. Marine mammals in the area would be habituated to the presence of vessels and therefore be expected to be able to detect and avoid construction vessels (see section 12.7.4.6). As a precautionary approach, the number of harbour porpoise, grey seal and harbour seal that could be at increased collision with vessels has been assessed based on the number of animals that could be present in the wind farm areas taking into account 95% avoidance rates. This is very precautionary, as it is highly unlikely that all marine mammals present in the wind farm areas would be at increased collision risk with vessels.

918. The CIA has determined that the number of harbour porpoise that could have a potential increased collision risk with vessels in OWF sites during construction would be 274 individuals, which represents 0.1% of the NS MU reference population (Table 12.88). The potential magnitude of the effect is assessed as **medium**, based on a

permanent effect with between 0.01% and 1% of the reference population likely to be exposed to the effect.

919. The CIA has determined that the number of grey seal that could have a potential increased collision risk with vessels in OWF sites during construction would be 12 individuals, which represents 0.05% of the reference population (Table 12.89). The potential magnitude of the effect is assessed as **medium**, based on a permanent effect with between 0.01% and 1% of the reference population likely to be exposed to the effect.

920. The CIA has determined that the number of harbour seal that could have a potential increased collision risk with vessels in OWF sites during construction would be one individual, which represents 0.002% of the reference population (Table 12.89). The potential magnitude of the effect is assessed as **low**, based on a permanent effect between 0.001% and 0.01% of the reference population likely to be exposed to the effect.

921. Any increase in vessel movements during the operation and maintenance of OWFs would be relatively small in relation to current ship movements in the area. Therefore, there is unlikely to be a significant increase in collision risk during the operation and maintenance of OWFs and as a result this has not been included in the CIA.

922. Wave and tidal arrays can pose a potential collision risk for marine mammals. The likelihood for collision may depend on many variables such as species, underwater visibility, detectability of the devices, the size and type of devices, the location, water depth and the rotation speed of the rotor blades. However, if there is the potential for significant collision risk for marine mammals then the wave or tidal development would be required to implement suitable mitigation to reduce the risk and any potential significant effects at the population level. Therefore, there should be no potential for any significant cumulative impacts and as a result this has not been included in the CIA.

923. All projects screened into the CIA (Appendix 12.3) have the potential to increase the amount of vessel activity over the range of each species, although there are already large numbers of vessel movements across the area. Therefore, for most of these projects any increase in vessel movements is likely to be relatively small in relation to current ship movements in the area.

924. Taking into account the location of the tidal and wave developments screened into the CIA (Appendix 12.3) and the mitigation that would be put in place at these

developments to reduce the risk of collision for marine mammals, the magnitude for all marine mammal species is also considered to be **low**.

925. The cumulative effects of all projects and activities other than OWFs have the potential to increase the collision risk for harbour porpoise, grey seal and harbour seal, therefore, as a precautionary approach, the magnitude for all marine mammal species is considered to be **low**.

Table 12.88 Quantified CIA for the potential increased collision risk with vessels for harbour porpoise during OWF construction

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site*	Potential number of harbour porpoise impacted based on 95% avoidance
Norfolk Vanguard	5	0	O[1]	0.888	592	26
Dogger Bank Zone Creyke Beck A	3	163	O	0.888	515	23
Dogger Bank Zone Creyke Beck B	3	193	O	0.888	599	27
Dogger Bank Zone Teesside A	3	180	N	0.837	562	24
Sofia	3	175	O[2]	0.888	593	26
East Anglia One	3	40	L	0.607	205	6
East Anglia THREE	3	0	L	0.607	301	9
Hornsea Project Two	3	125	O	0.888	462	21
Triton Knoll phase 1-3	3	288	O	0.888	146	6
Kincardine	3	535	R	0.607	110	3
Firth of Forth Phase 1 Seagreen Alpha	4	500	R	0.599	197	6
Firth of Forth Phase 1 Seagreen Bravo	4	500	R	0.599	194	6
Inch Cape	4	510	R	0.599	150	5
Neart na Gaoithe	4	475	R	0.599	105	3
Dounreay Ti	4	785	S	0.152	25	0
Moray Firth Western Development Area	4	660	S	0.152	226	2
Norfolk Boreas	5	30	O[3]	0.888	727	32
Hornsea Project THREE	5	80	O	0.888	695	31
Thanet Extension	5	165	L	0.607	73	2
East Anglia ONE North	5	30	L	0.607	206	6
East Anglia TWO	5	45	L	0.607	255	8

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site*	Potential number of harbour porpoise impacted based on 95% avoidance
Mermaid	3	125	N	0.837	16	1
Northwester 2	3	130	N	0.837	15	1
Delta Nordsee 1	3	300	M	0.277	N/A	N/A
Delta Nordsee 2 (OWP Delta Nordsee 2)	3	300	M	0.277	N/A	N/A
Borssele I and II	3	133	N	0.837	N/A	N/A
Borssele III and IV	3	123	N	0.837	N/A	N/A
Borssele Site V - Leeghwater - Innovation Plot	3	108	N	0.837	N/A	N/A
Total					**7,079km^2**	**274**
% of NS MU reference population (345,373 harbour porpoise)						**0.1%**

[1]NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore, higher density estimate from survey block O is used.
[2]Dogger Bank Zone Teesside B overlaps SCANS-III survey block O & N, but majority of site is in block O.
[3]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore, higher density estimate from survey block O is used.
*Source: http://www.4coffshore.com/

Table 12.89 Quantified CIA for the potential increased collision risk with vessels for grey seal and harbour seal during OWF construction

Name of Project	Country	Distance to NV (km)	Grey seal density estimate (No/km^2)	Harbour seal density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of grey seal impacted based on 95% avoidance	Potential number of harbour seal impacted based on 95% avoidance
Norfolk Vanguard	UK	0	0.002	0.0001	592	0.06	0.001
Dogger Bank Zone Creyke Beck A	UK	163	0.05	0.0004	515	1.29	0.004
Dogger Bank Zone Creyke Beck B	UK	193	0.09	0.001	599	2.70	0.01
Dogger Bank Zone Teesside A	UK	180	0.01	0.00004	562	0.28	0.0004
Sofia	UK	175	0.09	0.001	593	2.67	0.01

Name of Project	Country	Distance to NV (km)	Grey seal density estimate (No/km^2)	Harbour seal density estimate (No/km^2)	Area of OWF site (km^2)*	Potential number of grey seal impacted based on 95% avoidance	Potential number of harbour seal impacted based on 95% avoidance
East Anglia One	UK	40	0.001	0.0003	205	0.01	0.001
East Anglia THREE	UK	0	0.00009	0.00009	301	0.001	0.001
Hornsea Project Two	UK	125	0.08	0.008	462	1.85	0.07
Triton Knoll phase 1-3	UK	288	0.07	0.26	146	0.51	0.76
Norfolk Boreas	UK	30	0.0006	0.00006	727	0.02	0.001
Hornsea Project THREE	UK	80	0.08	0.008	695	2.78	0.11
Thanet Extension	UK	165	0.02	0.06	73	0.07	0.09
East Anglia ONE North	UK	30	0.0009	0.0006	206	0.01	0.002
East Anglia TWO	UK	45	0.01	0.002	255	0.13	0.01
Mermaid	Belgium	125	0.000002	0.00004	16	0.000002	0.00001
Northwester 2	Belgium	130	0.000002	0.00004	15	0.000002	0.00001
Delta Nordsee 1	Germany	300	0.000002	0.00004	5	0.000001	0.000004
Delta Nordsee 2 (OWP Delta Nordsee 2)	Germany	300	0.000002	0.00004	105	0.00001	0.00008
Borssele I and II	Netherlands	133	0.000002	0.00004	113	0.00001	0.00009
Borssele III and IV	Netherlands	123	0.000002	0.00004	122	0.00001	0.00010
Borssele Site V - Leeghwater - Innovation Plot	Netherlands	108	0.000002	0.00004	1	0.0000001	0.000001
Total					**6,308km^2**	**12**	**1**
% of reference population (22,290 grey seal; 43,161 harbour seal)						**0.05%**	**0.002%**

*Source: http://www.4coffshore.com/

12.8.8.1.1 Cumulative impact significance

926. Marine mammals would be habituated to the presence of vessels and would be able to detect and avoid vessels. Therefore, harbour porpoise, grey seal and harbour seal are considered to have a **low** sensitivity to the risk of a vessel strike (see section 12.7.4.6.1).

927. Based on the sensitivity of harbour porpoise, grey seal and harbour seal, and the potential magnitude of effect, the cumulative impact is assessed as having the potential to be **negligible** to **minor adverse** for the three species (Table 12.90).

Table 12.90 Cumulative assessment of impact significance of increased collision risk from vessels during OWF construction

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Increased collision risk from vessels during OWF construction	Harbour porpoise	Low	Medium to Low	Negligible to Minor	No mitigation required or proposed.	**Negligible to Minor**
	Grey seal	Low	Medium to Low	Negligible to Minor		**Negligible to Minor**
	Harbour seal	Low	Low to Negligible	Negligible to Minor		**Negligible to Minor**

12.9 Transboundary Impacts

928. The highly mobile nature of marine mammals species considered in this assessment means that there are potential transboundary impacts for each receptor. These transboundary impacts are already considered in the assessment, as the impacts for all species have been based on the relevant Management Units and reference populations.

929. For harbour porpoise the extent of the reference population includes UK, Dutch, German, French, Belgian, Danish and Swedish waters. For harbour seal the extent of the reference population includes UK, Dutch, German, Belgian and French waters. For grey seal the extent of the reference population includes UK, Dutch, German, Belgian, Danish and French waters.

12.10 Inter-Relationships

930. Inter-relationships are covered as part of the assessment, this section serves as a sign-posting for inter-relationships (Table 12.91).

Table 12.91 Marine mammal inter-relationships

Topic and description	Related Chapter	Where addressed in this Chapter	Rationale
Water Quality	Chapter 8 Water and Sediment Quality	Section 12.7.4.9 Section 12.7.6.7	Changes to water quality to water quality (e.g. increased suspended sediments) can affect marine mammals e.g. during foraging.
Prey species	Chapter 11 Fish and Shellfish Ecology	Section 12.7.4.8 Section 12.7.5.7 Section 12.7.6.6	Potential impacts on fish and shellfish could affect the prey resource for marine mammals
Vessel collision risk	Chapter 15 Shipping and Navigation	Section 12.7.4.6 Section 12.7.5.4 Section 12.7.6.4	Increased vessel traffic associated with the project could affect the level of collision risk for marine mammals

12.11 Interactions

931. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within the chapter take these interactions into account and for the impact assessments are considered conservative and robust. For clarity the areas of interaction between impacts are presented in Table 12.92 to Table 12.94, along with an indication as to whether the interaction may give rise to synergistic impacts.

932. Synergistic impacts of potential disturbance from underwater noise during construction from all noise sources at Norfolk Vanguard have been assessed as potential barrier effects (Table 12.92).

Table 12.92 Interaction between impacts during construction

Potential interaction between impacts											
Construction											
	1 Physical and auditory injury resulting from the underwater noise associated with UXO clearance	**2 Behavioural impacts resulting from the underwater noise associated with UXO clearance**	**3 Physical and auditory injury resulting from underwater noise during piling**	**4 Behavioural impacts resulting from underwater noise during piling**	**5 Behavioural impacts resulting from underwater noise during construction activities, other than piling**	**6 Behavioural impacts resulting from underwater noise and presence of vessels**	**7 Barrier effects as a result of behavioural impacts resulting from underwater noise associated with UXO clearance, piling, construction activities and vessels**	**8 Vessel interaction (collision risk)**	**9 Disturbance at seal haul-out sites**	**10 Changes to prey resource**	**11 Changes to water quality**
1 Physical and auditory injury resulting from the underwater noise associated with UXO clearance	-	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
2 Behavioural impacts resulting from the underwater noise associated with UXO clearance	Yes	-	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
3 Physical and auditory injury resulting from underwater noise during piling	Yes	Yes	-	Yes	Yes	Yes	Yes	No	No	Yes	No
4 Behavioural impacts resulting from underwater noise during piling	Yes	Yes	Ye	-	Yes	Yes	Yes	No	No	Yes	No
5 Behavioural impacts resulting from underwater noise during construction activities, other than piling	Yes	Yes	Yes	Yes	-	Yes	Yes	No	Yes	Yes	No
6 Behavioural impacts resulting	Yes	Yes	Yes	Yes	Yes	-	Yes	No	Yes	Yes	No

Potential interaction between impacts											
Construction											
	1 Physical and auditory injury resulting from the underwater noise associated with UXO clearance	2 Behavioural impacts resulting from the underwater noise associated with UXO clearance	3 Physical and auditory injury resulting from underwater noise during piling	4 Behavioural impacts resulting from underwater noise during piling	5 Behavioural impacts resulting from underwater noise during construction activities, other than piling	6 Behavioural impacts resulting from underwater noise and presence of vessels	7 Barrier effects as a result of behavioural impacts resulting from underwater noise associated with UXO clearance, piling, construction activities and vessels	8 Vessel interaction (collision risk)	9 Disturbance at seal haul-out sites	10 Changes to prey resource	11 Changes to water quality
from underwater noise and presence of vessels											
7 Barrier effects as a result of behavioural impacts resulting from underwater noise associated with UXO clearance, piling, construction activities and vessels	Yes	Yes	Yes	Yes	Yes	Yes	-	No	Yes	Yes	No
8 Vessel interaction (collision risk)	No	No	No	No	No	No	No	-	No	No	No
9 Disturbance at seal haul-out sites	No	No	No	No	Yes	Yes	Yes	No	-	No	No
10 Changes to prey resource	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	-	Yes
11 Changes to water quality	No	No	No	No	No	No	No	No	No	Yes	-

Table 12.93 Interaction between impacts during operation and maintenance

Operation	1 Behavioural impacts resulting from the underwater noise associated with operational turbines	2 Behavioural impacts resulting from the underwater noise associated with maintenance activities	3 Behavioural impacts resulting from underwater noise and presence of vessels	4 Vessel interaction (collision risk)	5 Disturbance at seal haul-out sites	6 Entanglement in floating foundations	7 Changes to prey resource
1 Behavioural impacts resulting from the underwater noise associated with operational turbines	-	Yes	Yes	No	No	No	Yes
2 Behavioural impacts resulting from the underwater noise associated with maintenance activities	Yes	-	Yes	No	Ye	No	Yes
3 Behavioural impacts resulting from underwater noise and presence of vessels	Yes	Yes	-	No	Yes	No	Yes
4 Vessel interaction (collision risk)	No	No	No	-	No	No	No
5 Disturbance at seal haul-out sites	No	Yes	Yes	No	-	No	No
6 Entanglement in floating foundations	No	No	No	No	No	-	No
7 Changes to prey resource	Yes	Yes	Yes	No	No	No	-

Table 12.94 Interaction between impacts during decommissioning

Decommissioning
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.

12.12 Summary

933. The construction, operation and decommissioning phases of Norfolk Vanguard would cause a range of effects on marine mammals which are summarised in Table 12.95.

Table 12.95 Summary of potential impacts for marine mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Impact 1: Underwater UXO Clearance						
- Permanent auditory injury	Harbour porpoise	High	Medium	Major	MMMP for UXO clearance.	**Minor**
	Grey seal & harbour seal	High	Low to Negligible	Moderate to Minor		**Minor**
- TTS and fleeing response	Harbour porpoise, grey seal & harbour seal	Medium	Negligible	Minor	MMMP for UXO clearance.	**Minor**
- Disturbance	Harbour porpoise	Medium	Negligible	Minor	SIP for SNS cSAC	**Minor**
	Grey seal	Medium	Low	Minor		**Minor**
	Harbour seal	Medium	Negligible	Minor		**Minor**
Impact 2: Underwater Noise during Piling						
- PTS from single strike of starting hammer energy	Harbour porpoise	High	Negligible	Minor	MMMP for piling	**Minor**
	Grey seal & harbour seal	High	Negligible	Minor		**Minor**
- PTS from single strike of maximum hammer energy	Harbour porpoise	High	Negligible	Minor	MMMP for piling including embedded mitigation	**Minor**
	Grey seal & harbour seal	High	Negligible	Minor		**Minor**
- PTS from Cumulative SEL	Harbour porpoise	High	Negligible to Low	Minor to Moderate	MMMP for piling including embedded mitigation	**Minor**
	Grey seal & harbour seal	High	Negligible	Minor		**Minor**
- TTS and fleeing response	Harbour porpoise	Medium	Negligible	Minor	MMMP for piling	**Minor**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Grey seal & harbour seal	Medium	Negligible	Minor	including embedded mitigation	**Minor**
- Disturbance during piling for single installation	Harbour porpoise	Medium	Negligible	Minor	SIP	**Minor**
	Grey seal & harbour seal	Medium	Negligible	Minor		**Minor**
- Disturbance during concurrent piling	Harbour porpoise	Medium	Negligible to Low	Minor		**Minor**
	Grey seal & harbour seal	Medium	Negligible	Minor		**Minor**
- Possible behavioural	Harbour porpoise	Low	Low	Minor		**Minor**
Impact 3: Underwater Noise during Other Construction Activities						
- Disturbance	Harbour porpoise, grey seal & harbour seal	Medium	Negligible	Minor	No mitigation required	**Minor**
Impact 4: Vessel Underwater Noise and Disturbance						
- Disturbance	Harbour porpoise	Low	Negligible	Negligible	No mitigation required	**Negligible**
	Grey seal & harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 5: Barrier Effects from Underwater Noise						
- Disturbance	Harbour porpoise	Medium	Low	Minor	SIP	**Minor**
	Grey seal	Medium	Negligible	Minor		**Minor**
	harbour seal	Medium	Negligible	Minor		**Minor**
Impact 6: Vessel Collision Risk						
- Increased collision risk	Harbour porpoise	Low	Medium	Minor	No further mitigation	**Minor**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Grey seal & harbour seal	Low	Low	Minor	proposed other than good practice	**Minor**
Impact 7: Disturbance at Seal Haul-Out Sites						
- Disturbance	Grey seal & harbour seal	Low	Negligible	Negligible	No mitigation required	**Negligible**
Impact 8: Changes to Prey Resource						
- Disturbance	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor	No further mitigation currently required, beyond embedded mitigation to reduce piling noise impacts	**Negligible to Minor**
	Grey seal	Low	Negligible	Negligible		**Negligible**
Impact 9: Changes to Water Quality						
- Increased suspended sediment	Harbour porpoise	Negligible	Negligible	Negligible	Embedded mitigation	**Negligible**
	Grey seal & harbour seal	Negligible	Negligible	Negligible		**Negligible**
Operation						
Impact 1: Underwater Noise from Operational Turbines						
- Disturbance	Harbour porpoise	Low	Low	Minor	No mitigation required	**Minor**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 2: Underwater Noise from Maintenance Activities						
- Disturbance	Harbour porpoise	Medium	Negligible	Minor	No mitigation required	**Minor**
	Grey seal & harbour	Medium	Negligible	Minor		**Minor**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	seal					
Impact 3: Vessel Underwater Noise and Disturbance during Operation and Maintenance						
- Disturbance	Harbour porpoise	Low	Negligible	Negligible	No mitigation required	**Negligible**
	Grey seal & harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 4: Vessel Collision Risk						
- Increased collision risk	Harbour porpoise	Low	Medium	Minor	No further mitigation proposed other than good practice	**Minor**
	Grey seal & harbour seal	Low	Low	Minor		**Minor**
Impact 5: Disturbance at Seal Haul-Out Sites						
- Disturbance	Grey seal & harbour seal	Low	Negligible	Negligible	No mitigation required	**Negligible**
Impact 6: Entanglement in Floating Foundations						
- Entanglement	Harbour porpoise	Negligible	Low	Negligible	No mitigation currently required or proposed	**Negligible**
	Grey seal & harbour seal	Negligible	Low	Negligible		**Negligible**
Impact 7: Changes to Prey Resource during Operation and Maintenance						
- Disturbance	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor	No mitigation required	**Negligible to Minor**
	Grey seal	Low	Negligible	Negligible		**Negligible**
Decommissioning						
Impact 1: Underwater Noise						

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
- Disturbance	Harbour porpoise, grey seal & harbour seal	Medium	Low	Minor	No further mitigation required	**Minor**
Impact 2: Barrier Effects from Underwater Noise						
- Disturbance	Harbour porpoise, grey seal & harbour seal	Medium	Low	Minor	No mitigation required	**Minor**
Impact 3: Vessel Underwater Noise and Disturbance						
- Disturbance	Harbour porpoise	Low	Low	Minor	No mitigation required	**Minor**
	Grey seal & harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 4: Vessel Collision Risk						
- Increased collision risk	Harbour porpoise	Low	Medium	Minor	No further mitigation proposed other than good practice	**Minor**
	Grey seal & harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 5: Disturbance at Seal Haul-Out Sites						
- Disturbance	Grey seal & harbour seal	Low	Negligible	Negligible	No mitigation required	**Negligible**
Impact 6: Changes to Prey Resource						
- Disturbance	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor	No mitigation required	**Negligible to Minor**
	Grey seal	Low	Negligible	Negligible		**Negligible**
Impact 7: Changes to Water Quality						

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
- Increased suspended sediment	Harbour porpoise, grey seal & harbour seal	Negligible	Negligible	Negligible	Embedded mitigation	**Negligible**
Cumulative						
Impact 1: Underwater noise during piling						
- Disturbance	Harbour porpoise	Medium	Low to Medium for single and concurrent piling	Minor to Moderate for single and concurrent piling	Project level mitigation outlined above, including SIP and any strategic mitigation, if required	**Minor**
	Grey seal	Medium	Low	Minor		**Minor**
	Harbour seal	Medium	Negligible	Negligible		**Negligible**
Impact 2: Underwater noise for all other noise sources						
- Disturbance	Harbour porpoise	Medium	Low	Minor	No further mitigation currently proposed	**Minor**
	Grey seal	Medium	Low	Minor		**Minor**
	Harbour seal	Medium	Low	Minor		**Minor**
Summary of impact 1 and 2 combined: Underwater noise for all other noise sources including piling at Norfolk Vanguard						
- Disturbance	Harbour porpoise	Medium	Low	Minor	Project level mitigation outlined above, including SIP and any strategic mitigation, if required	**Minor**
	Grey seal	Medium	Medium	Moderate		**Minor**
	Harbour seal	Medium	Negligible	Minor		**Minor**
Impact 3: Changes to prey availability						
- Disturbance	Harbour porpoise	Low to Medium	Low	Minor	No further mitigation proposed.	**Minor**
	Grey seal	Low	Medium	Minor		**Minor**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 4: Collision risk – vessels and tidal devices						
- Increased collision risk	Harbour porpoise	Low	Medium to Low	Minor	No further mitigation proposed other than good practice	**Negligible to Minor**
	Grey seal	Low	Medium to Low	Minor		**Negligible to Minor**
	Harbour seal	Low	Low to Negligible	Negligible to Minor		**Negligible to Minor**

12.12.1 Summary of mitigation

12.12.1.1 Embedded mitigation

934. Embedded mitigation would include soft-start and ramp-up of piling activity in order to minimise potential impacts on physical and auditory injury.

935. The Project Environmental Management Plan (PEMP) (document reference 8.14) will outline the embedded mitigation measures in relation to water quality impacts, respectively. These will be developed in consultation with the relevant statutory stakeholders.

12.12.1.2 Further mitigation

12.12.1.2.1 MMMP for piling

936. The MMMP for piling (in accordance with the draft MMMP, document 8.13) will be developed in the pre-construction period and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO. The MMMP for piling will include details of the embedded mitigation, for the soft-start and ramp-up, as well as details the mitigation zone and the mitigation measures to reduce the risk of any physical or permanent auditory injury (PTS) to marine mammals during all piling operations. A mitigation zone will be established to ensure marine mammals are outside the range for PTS (see section 12.7.1.1.2).

12.12.1.2.2 MMMP for UXO clearance

937. A detailed MMMP for UXO clearance will be developed in the pre-construction period. The MMMP for UXO clearance will ensure there are adequate mitigation measures to prevent the risk of any physical or permanent auditory injury (PTS) to marine mammals. The MMMP for UXO clearance will be developed in the pre-construction period, when there is more detailed information on what UXO clearance could be required and what the most suitable mitigation measures are, based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO.

12.12.1.2.3 In Principle Site Integrity Plan

938. In addition to the MMMP for piling and MMMP for UXO clearance, a Norfolk Vanguard Southern North Sea cSAC Site Integrity Plan (SIP) will be developed and an in principle SIP (document reference 8.17) is provided with the DCO application. The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SNS cSAC.

939. The SIP will be developed in the pre-construction period and will be based upon best available information and methodologies at that time, in consultation with the relevant SNCBs and MMO.

12.12.1.3 Mitigation for cumulative impacts

940. Mitigation for cumulative disturbance impacts will be discussed further with the relevant SNCBs and the MMO.

941. In order to address the overall potential cumulative impact, Norfolk Vanguard Limited is open to discussing with the SNCBs and MMO a possible strategic approach to mitigation, if required. This would be addressed through the SIP (document reference 8.17) and would be based on the final design of Norfolk Vanguard and the actual cumulative impact scenarios resulting from the final design and programmes of other projects.

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