East Anglia ONE North Offshore Windfarm

Chapter 11

Marine Mammals

Environmental Statement
Volume 1

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Glossary of Acronyms

µPa	Micro pascal
AA	Appropriate Assessment
ADD	Acoustic Deterrent Device
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BEIS	Business Energy and Industrial Strategy
BSI	British Standards Institution
CBD	Convention on Biological Diversity
CCW	Countryside Council for Wales
CEDA	Central Dredging Association
Cefas	Centre for Environment, Fisheries and Aquaculture Science
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
CF	Correction Factor
cm	Centimetre
CRoW	Countryside Rights of Way
cSAC	candidate Special Area of Conservation
CSIP	Cetacean Strandings Investigation Programme
cum	Cumulative
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
DOW	Dudgeon Offshore Windfarm
EAOL	East Anglia ONE Limited
EAOW	East Anglia Offshore Wind
EATL	East Anglia THREE Ltd
EC	European Commission
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
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
GS	Grey seal
GSD	Ground Sampling Distance
HDD	Horizontal Directional Drilling
HF	High Frequency Cetaceans
HP	Harbour porpoise
HRA	Habitats Regulation Assessment
HS	Harbour seal
Hz	Hertz
IAMMWG	Inter-Agency Marine Mammal Working Group

ICES	Institute of Estuarine and Coastal Studies
IEEM	Institute for Ecology and Environmental Management
INSPIRE	Impulsive Noise Propagation and Impact Estimator
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
LSE	Likely Significant Effect
m	Metre
m/s	Metres per second
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOs	Marine Mammal Observers
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
MU	Management Unit
MW	Megawatt
N/A	Not Applicable
NE	Natural England
NEQ	Net Explosive Quantities
nm	Nautical Miles
NMFS	National Marine Fisheries Services
NNR	National Nature Reserve
NOAA	National Oceanic and Atmospheric Administration
NPS	National Policy Statement
NS	North Sea
NSIP	Nationally Significant Infrastructure Projects
NW	North West
O&M	Operation and Maintenance
OMR	Offshore Marine Regulations
OSPAR	Oslo and Paris Convention for the Protection of the Marine Environment
PAM	Passive Acoustic Monitoring
PDV	Phocine Distemper Virus
PEIR	Preliminary Environmental Information Report
PTS	Permanent Threshold Shift
PW	Pinnipeds in Water
QA	Quality Assurance
RMS	Root Mean Square
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Sea
SCI	Site of Community Importance
SCOS	Special Committee on Seals
SD	Standard Deviation
SE	South East
SEL	Sound Exposure Level
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body

SNS	Southern North Sea
SoS	Secretary of State
SPL	Sound Pressure Level
TNT	Trinitrotoluene
TSEG	Trilateral Seal Expert Group
TSHD	Trailing Suction Hopper Dredger
TTS	Temporary Threshold Shift
TWT	The Wildlife Trust
UK	United Kingdom
UXO	Unexploded Ordnance
WDC	Whale and Dolphin Conservation
WF	Windfarm
WODA	World Organisation of Dredging Associations
WWT	Wildfowl and Wetlands Trust
ZEA	Zonal Environmental Appraisal

Glossary of Terminology

Applicant	East Anglia ONE North Limited
candidate Special Area of Conservation	cSACs are sites that have been submitted to the European Commission, but not yet formally adopted.
Cetacean	The order Cetacean includes whales, dolphins and porpoises, collectively known as cetaceans.
Construction, operation and maintenance platform	A fixed offshore structure required for construction, operation, and maintenance personnel and activities.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and the information required to support HRA.
East Anglia ONE North project	The proposed project consisting of up to 67 wind turbines, up to four offshore electrical platforms, up to one offshore construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia ONE North windfarm site	The offshore area within which wind turbines and offshore platforms will be located.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms. These cables will include fibre optic cables.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables.
Management Unit	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).
Marking buoys	Buoys to delineate spatial features / restrictions within the offshore development area.
Met mast	An offshore structure which contains metrological instruments used for wind data acquisition.
Offshore development area	The East Anglia ONE North windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore cable corridor	This is the area which will contain the offshore export cables between offshore electrical platforms and transition bays located at landfall.
Offshore electrical infrastructure	The transmission assets required to export generated electricity to shore. This includes inter-array cables from the wind turbines to the offshore electrical platforms, offshore electrical platforms, and export cables from the offshore electrical platforms to the landfall.
Offshore electrical platform	A fixed structure located within the windfarm 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 would bring electricity from the offshore electrical platforms to the landfall. These cables will include fibre optic cables.
Offshore infrastructure	All of the offshore infrastructure including wind turbines, platforms, and cables.
Offshore platform	A collective term for the offshore operation and maintenance platform and the offshore electrical platforms.

Platform link cable	An electrical cable which links one or more offshore platforms. These cables will include fibre optic cables.
Pinniped	Pinnipeds comprise of the following families: Odobenidae (walrus); Otariidae (eared seals, sea lions, and fur seals); and Phocidae (earless seals). Pinnipeds are more broadly known as “seals”.
Sites of Community Importance	SCIs are sites that have been adopted by the European Commission but not yet formally designated by the government of each country.
Special Areas of Conservation	SACs are sites that have been adopted by the European Commission and formally designated by the government of each country in whose territory the site lies.

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11 Marine Mammals

11.1 Introduction

1. This chapter of the Environmental Statement (ES) outlines the existing environment occupied by marine mammals, including pinnipeds (seals) and cetaceans (whales, dolphins and porpoises) and assesses the potential impacts of the proposed East Anglia ONE North project during construction, operation and decommissioning phases. Mitigation measures and residual impacts are presented where appropriate.

2. 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 11.2***.

3. This assessment also considers information from, and refers to, the following chapters:

- ***Chapter 3***: ***Policy and Legislative Context***;
- ***Chapter 5***: ***EIA Methodology***;
- ***Chapter 6***: ***Project Description;***
- ***Chapter 10***: ***Fish and Shellfish Ecology***; and
- ***Chapter 14***: ***Shipping and Navigation***.

4. This chapter is supported by the following Appendices:

- ***Appendix 11.1: Consultation Responses;***
- ***Appendix 11.2: Marine Mammal Information and Survey Data;***
- ***Appendix 11.3: Marine Mammal Cumulative Impact Assessment (CIA) screening;*** and
- ***Appendix 11.4: Underwater Noise Modelling Report.***

11.2 Consultation

5. Consultation is a key feature of the Environmental Impact Assessment (EIA) process, and continues throughout the lifecycle of a project, from its initial stages through to consent and post-consent.

6. To date, consultation with regards to marine mammals has been undertaken as part of the Expert Topic Groups (ETGs), described within ***Chapter 5 EIA Methodology***, with meetings held in April 2017, March 2018, January 2019 and June 2019, and through the submission of the East Anglia ONE North Scoping Report (SPR 2017a) and the Preliminary Environmental Information Report

(PEIR) (SPR 2019). Feedback received through this process has been incorporated into the ES where appropriate and this final assessment submitted with the Development Consent Order (DCO) application has been updated where relevant. The responses received from stakeholders with regards to the Scoping Report, PEIR, as well as feedback from ETGs, are summarised in ***Appendix 11.1***, including details of how these have been taken account of within this chapter.

7. Ongoing public consultation has been conducted through a series of Public Information Days (PIDs) and Public Meetings. PIDs have been held throughout Suffolk in November 2017, March 2018, June / July 2018 and February / March 2019. A series of stakeholder engagement events were also undertaken in October 2018 as part of consultation Phase 3.5. Details of the consultation phases are discussed further in ***Chapter 5 EIA Methodology. Table 11.1*** shows public consultation feedback pertaining to marine mammals. Full details of the proposed East Anglia ONE North project consultation process will be presented in the Consultation Report which is provided as part of the DCO application.

Table 11.1 Public Consultation Responses Relevant to Marine Mammals

Topic	Response / where addressed in the ES
Phase 1; Phase 2; Phase 3; and Phase 3.5	
No responses	
Phase 4	
• Noise and vibration impact on marine mammals.	Impacts related to noise and vibration from construction and operation activities are considered in ***sections 11.6.1*** and ***11.6.2*** respectively.
• Impact on harbour porpoise in the Southern North Sea SAC. • Impacts on harbour porpoises.	The Information to Support the Appropriate Assessment report (document reference 5.3) has been produced in conjunction with an In-principle Site Integrity Plan (SIP) for the Southern North Sea (SNS) Special Area of Conservation (SAC). The former assesses the potential impact on the SNS SAC while the latter provides details of the approach and mitigation to avoid any significant disturbance of harbour porpoise adversely affecting the integrity of the SNS SAC. Impacts on harbour porpoises are also considered within ***section 11.6***.
• Impacts on seals at Thorpeness.	An assessment of the potential impact on seals in the vicinity of the offshore development area is considered throughout ***section 11.6***.

11.3 Scope

11.3.1 Study Area

8. Marine mammals are highly mobile and transitory in nature; therefore, it is necessary to examine species occurrence not only within the East Anglia ONE North offshore development area, but also over the wider North Sea region. The key marine mammal species in this area of the North Sea are assessed within ***Appendix 11.2***. For each species of marine mammal that could be present in and around the East Anglia ONE North offshore development area, the following study areas have been defined based on the relevant Management Units (MUs), current knowledge and understanding of the biology of each species and taking into account the feedback received during consultation (***Appendix 11.1***).

- 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 United Kingdom (UK) East Coast MUs, and the Wadden Sea region; and
- Harbour seal South-east England MU and the Wadden Sea region.

9. 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). The study areas, MUs and reference populations (see ***section 11.5*** and ***Appendix 11.2***) used in the assessment have been determined based on the most relevant information and scale at which potential impacts from the proposed East Anglia ONE North project alone and cumulatively with other plans and projects could occur.

10. The status and activity of marine mammals known to occur within or adjacent to the offshore development area 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.

11.3.2 Worst-Case

11. The design of the proposed East Anglia ONE North project (including number of wind turbines, layout configuration, requirement for scour protection, electrical design, etc.) is not yet fully determined, and may not be known until sometime after the DCO has been granted. Therefore, in accordance with the requirements of the Project Design Envelope (also known as the Rochdale Envelope) approach to EIA (Planning Inspectorate 2018) (as discussed in ***Chapter 5 EIA Methodology***), realistic worst-case scenarios in terms of potential effects upon

marine mammals are adopted to undertake a precautionary and robust impact assessment.

12. Definition of the worst-case scenarios has been made from consideration of the proposed East Anglia ONE North project that is presented in ***Chapter 6 Project Description***, alongside the mitigation measures that have been embedded in the design (***section 11.3.3.2***).

13. The offshore development area consists of:

- The offshore wind turbines and their associated foundations;
- Scour protection around foundations as required;
- Offshore electrical platforms supporting required electrical equipment, possibly also incorporating offshore facilities;
- Up to one meteorological mast (met mast) and associated foundations for monitoring wind speeds during the operational phase (additional to existing met masts within the former East Anglia Zone);
- Up to one construction, operation and maintenance platform may be required to house construction, operation and maintenance personnel and equipment; and
- Subsea cables comprising inter-array, platform link and offshore export cables.

14. The worst-case scenario is based on wind turbines with a blade tip height of between 250 and 300m, therefore, the worst-case is based on either 53 x 300m or 67 x 250m wind turbines.

15. A range of foundation options are currently being considered, these include:

- For wind turbines:
  - monopiles (either piled or with suction caisson);
  - three or four-legged jackets (either pin-piles or suction caissons); or
  - gravity base structure (GBS).
- For the met mast, the foundation options are jacket with pin-piles, jacket with suction caisson, gravity base, suction caisson or monopile; and
- For offshore electrical platforms, the foundation options are jacket with pin-piles, jacket with suction caisson or gravity base;
- For the construction, operation and maintenance platform, the foundation options are jacket with pin-piles, jacket with suction caisson or gravity base.

16. The realistic worst-case scenario for each category of potential impact on marine mammals has been determined (***Table 11.2***). Only those design parameters with

the potential to influence the level of impact on marine mammals are included in ***Table 11.2***.

17. Details on mitigation, including embedded mitigation, are presented in ***section 11.3.3***.

18. The realistic worst-case scenarios identified here also apply to the Cumulative Impact Assessment (CIA). When the worst-case scenarios for the proposed East Anglia ONE North 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 11.7***).

Table 11.2 Worst-Case Parameters for Marine Mammal Receptors

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
Construction			
Impacts 1 and 2 Underwater noise during unexploded ordnance (UXO) clearance	Number of UXO	Up to 80	Indicative only. Based on best available information from East Anglia ONE.
	Type and size of UXO	Up to 700kg (net explosive quantities (NEQ))	Indicative only. Based on East Anglia ONE UXO survey. A detailed UXO survey will be completed prior to construction.
Underwater noise during geophysical surveys	Area	Wind farm site and cable corridor	Duration and timing / season currently unknown. However, as outlined in ***Section 11.7***, the potential disturbance of during offshore windfarm construction has been assessed based on the disturbance during piling and for other construction activities, therefore the potential for any disturbance during any geophysical surveys at these sites has already been taken into account (i.e. the areas of potential disturbance has already been included / covered as part of these assessments).

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
Impacts 3 and 4 Underwater noise during piling (represents worst-case scenario for underwater noise, alternative foundation types are also considered)	Number of wind turbines	Up to 67 (250m wind turbines) or 53 (300m wind turbines)	
	Number of offshore platforms	4 x Offshore Electrical platforms 1 x Met mast 1 x Offshore construction, operation and maintenance platform = 6	
	Wind turbine foundation options	Monopile Four-legged jacket = pin-piles	Hammer piled foundations represent the worst-case scenario for underwater noise.
	Platform foundation options	Offshore electrical platforms = jacket with pin-piles Met mast = monopile; or jacket with pin-piles Construction, operation and maintenance = jacket with pin-piles	
	Proportion of foundations that are piled	100%	The maximum proportion of hammer piled foundations represents the worst-case scenario for underwater noise.
	Number of piles per infrastructure type	Wind turbines = 1 monopile or 4 pin-piles Offshore electrical platforms = 8 pin-piles per platform Met mast = 1 monopile or 4 pin-piles Construction, operation and maintenance platform = 8 pin-piles per platform	

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
	Number of piles for wind turbines	250m wind turbines = 67 monopiles or 268 pin-piles 300m wind turbines = 53 monopiles or 212 pin-piles	Maximum number of pin-piles for all wind turbine foundations is 268
	Number of piles for offshore platforms	Offshore electrical platforms = 4 x 8 pin-piles = 32 pin-piles Met mast = 1 monopile or 4 pin-piles Construction, operation and maintenance platform = 8 pin-piles	Maximum number of pin-piles for all platform foundations is 44
	Total number of piled foundations	Maximum number of pin-piles = 268 (250m wind turbines) + 44 (platforms) = 312; Or Maximum number of monopiles = 67 (250m wind turbines) + 1 (met mast) = 68; plus 40 pin-piles for platforms.	
	Hammer energy - monopiles	Starting hammer energy of 400kJ will be used for 10 minutes. Ramp up will then be undertaken for at least 20 minutes to 80% of the maximum hammer energy applied. Following the ramp-up, hammer energy can increase to 4,000kJ if required until target penetration depth is reached. Maximum hammer energy applied = 4,000kJ for 300m wind turbines with 15m diameter monopile.	This is the worst-case scenario with potential underwater noise impacts greater than those for 67 250m wind turbine monopiles using a maximum applied hammer energy of 3,000kJ. If a hammer model is used that can generate energy levels greater than 4,000kJ, the hammer energy output will be modulated to a maximum of 4,000kJ.
	Hammer energy – pin-piles	Starting hammer energy of 240kJ will be used for 10 minutes. Ramp up will then be undertaken for at least 20	This is the worst-case scenario with potential underwater noise impacts

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
		minutes to 80% of the maximum hammer energy applied. Following the ramp-up, hammer energy can increase to 2,800kJ if required until target penetration depth is reached. Maximum hammer energy applied = 2,400kJ for 4.6m diameter pin-piles (300m wind turbines or platforms).	greater than those for 67 250m wind turbine pin-piles with the maximum applied hammer energy of 1,800kJ. If a hammer model is used that can generate energy levels greater than 2,400kJ, the hammer energy output will be modulated to a maximum of 2,400kJ.
	Pile diameter - monopiles	Maximum monopile diameter of 15m for 300m wind turbines.	15m diameter is the worst-case scenario for monopiles, with potential underwater noise impacts greater than 13m diameter monopile for 250m wind turbines and 8m diameter monopile for met mast.
	Pile diameter – pin-piles	Maximum pin-pile diameter of 4.6m for 300m wind turbines and platforms (offshore electrical and construction, operation and maintenance platforms).	This is the worst-case, with the greatest potential underwater noise impact ranges for the installation of pin-piles.
	Total piling time – per wind turbine foundation for monopiles (including soft-start and ramp-up and providing allowance for issues such as low blow rate, refusal, etc.)	325 minutes (5.42hrs) x 53 (300m wind turbine) monopiles = 287.25 hours (12 days)	The maximum hammer piling duration of 287.25 hours (12 days) represents the temporal worst-case scenario for the installation of monopiles for the 300m wind turbines (this includes 10 minute soft-start and 20 minute ramp-up). This is greater than the maximum hammer piling duration of 122.8 hours for the installation of monopiles for the

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
			250m wind turbines (110 minutes, including soft-start and ramp-up x 67).
	Total piling time – per wind turbine foundation for pin-piles (including soft-start and ramp-up and providing allowance for issues such as low blow rate, refusal, etc.)	199 minutes (3.32 hours) x 4 pin-piles x 53 (300m wind turbines) = 703.8 hours (29.3 days)	The maximum hammer piling duration of 703.8 hours (29.3 days) represents the temporal worst-case scenario for the installation of pin-piles for the 300m wind turbines (this includes 10 minute soft-start and 20 minute ramp-up). This is greater than the maximum hammer piling duration of 567.3 hours for the installation of pin-piles for the 250m wind turbines (127 minutes, including soft-start and ramp-up x 67 x 4).
	Total piling time – per platform foundation (including soft-start and ramp-up and providing allowance for issues such as low blow rate, refusal, etc.)	199 minutes x 8 pin-piles x 4 offshore electrical platforms = 106.1hours 199 minutes x 8 pin-piles x 1 construction, operation and maintenance platform = 26.5hours 127 minutes x 4 pin-piles x 1 Met mast = 8.5hours Total = 141 hours (up to 6 days)	The maximum hammer piling duration of 141 hours (6 days) represents the temporal worst-case scenario for the installation of the platforms (including soft-start and ramp-up).
	Maximum total active piling time for wind turbines and platforms	844.8 hours (35.2 days)	Based on the worst-case scenario of pin-piles for wind turbines (29.3 days) and platforms (6 days).
	Activation of Acoustic Deterrent Devices (ADDs)	For example, 10 minutes per pile.	Indicative only. If required, the ADDs will be activated prior to the soft-start to

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
		Up to 52 hours (up to 2.2 days) for 312 pin-piles	reduce the risk of auditory injury from the first single strike of the soft-start. This is greater than up to 18 hours for 68 monopiles and 40 offshore platform pin piles.
	Concurrent piling events	None	Concurrent piling will not be conducted at East Anglia ONE North
Impact 5 Underwater noise from activities such as seabed preparations, cable installation and rock dumping	Cable installation methods	Trenching (potential noisiest cable installation method)	
	Total export cable length	152km (2 cables, 76km each)	
	Inter-array cable length	200km	
	Platform cable link length	75km (up to 7 cables, 15km each)	
	Maximum number of inter-array cable laying vessels on site	3	
	Maximum number of export cable laying and support vessels on site	5	
Impacts 6 and 8 Vessels:	Approximate number of vessels on site at any one time during construction	74	

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
Interactions and collision risk; and Underwater noise and disturbance from vessels	Indicative number of movements	Approximate total trips: 3,335 Average trips per year: 1,488 Average trips per month: 124	Indicative number of movements based on approximate 27-month offshore construction period.
	Vessel types	Vessels could include: Dredging vessels Tugs and storage barges Jack-up vessels Dynamic Position (DP) Heavy Lift Vessels (HLV) Support Vessels Platform installation vessels Accommodation vessels Windfarm service vessels Supply vessels Inter-array cable laying vessel Export cable laying vessels Export cable support vessels Pre-trenching / backfilling vessel Cable jetting and survey vessels Workboats	

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
	Port locations	To be determined post consent.	Vessel traffic to and from port would likely become integrated in existing shipping routes.
Impact 7 Barrier effects caused by underwater noise	Maximum impact ranges associated with underwater noise	The maximum spatial area of potential impact and the maximum duration for any potential barrier effects are considered in relation to barrier effect.	
Impact 9 Changes to prey resources	Impacts upon prey species	Physical disturbance and temporary loss of sea bed habitat = up to 10.6km^2 Increased suspended sediments and sediment re-deposition from seabed preparation, sand wave levelling and trenching dredging requirements = approximately 0.004km^3 Underwater noise during piling = parameters as outlined above. Underwater noise from activities, including UXO clearance = parameters as outlined above.	See ***ES Chapter 10 Fish and Shellfish Ecology***. Physical disturbance and temporary loss of sea bed habitat based on maximum potential areas for preparation area for wind turbines and platform foundation installation, cable installation, footprint of jack up barges and boulder clearance. The worst-case suspended sediment and deposition is modelled in ***ES Chapter 7 Marine Geology, Oceanography and Physical Processes***, based on maximum are of seabed preparation, sand wave levelling, trenching / dredging requirements and drill arisings.

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
Operation			
Impact 1 Underwater noise from operational wind turbines	Number of wind turbines	Up to 67 (250m wind turbines) or 53 (300m wind turbines)	
Impact 2 Underwater noise from maintenance activities such as cable repairs and rock dumping	Parameters for any cable lengths or areas requiring any additional rock dumping or cable burial are unknown. The following estimates are assumed: Repair and reburial of one array cable of up to 4km length every 5 years. Repair and reburial of up to 300m of export cable less than once every five years.		
	Annual number of maintenance activities at individual wind turbines requiring the use of a jack-up vessel.	0.5 per annum for 67 wind turbines = 33.5 visits by a jack-up vessel per annum.	
	Annual number of maintenance activities requiring the use of a cable laying vessel (inter-array, platform link and export cable)	5	
	Annual number of geophysical surveys required for non-intrusive	4	

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
	inspection (for example, of cable burial / scour).		
Impacts 3 and 4 Vessels: Interactions and collision risk; and Underwater noise and disturbance from vessels	Number of trips made by support vessels to the windfarm per year	647	Maximum potential for risk from disturbance or collisions.
Impact 5 Changes to prey resources	Impacts upon prey species	Permanent habitat loss = approximately 1.9km^2. Increased suspended sediments and sediment re-deposition = 0.0003km^3 Underwater noise = parameters as outlined above Electromagnetic fields (EMF) = 427km maximum cable length (as outlined above), buried to a depth of 1m to 3m.	See ***ES Chapter 10 Fish and Shellfish Ecology***. The overall total footprint which could be subject to permanent habitat loss from gravity based foundations, platform foundations, scour protection and cable protection. The maximum amount of suspended sediment that would be released into the water column due to changes in tidal regime around infrastructure.

Potential Effect	Parameter	Maximum worst-case	Justification / Rationale
Decommissioning			
Impacts 1 and 2 Underwater noise from foundation removal (e.g. cutting)	Assumed to be no worse than for construction (with no pile driving) Explosives will not be used, assumed piles cut off 1m below seabed level and all wind turbine components above seabed level removed. All buried array and offshore export cables would be left *in situ* while unburied sections would be cut at the ends and removed. Scour and cable protection would also be left *in situ.*		
Impacts 3 and 4 Vessels: Interactions and collision risk; and Underwater noise and disturbance from vessels	Vessel types, movements and numbers assumed to be similar or less than construction phase.		
Impact 5 Barrier effects caused by underwater noise	Maximum impact ranges associated with underwater noise.		
Impact 6 Changes to prey resources	Assumed to be no worse than for construction.		

11.3.3 Mitigation

11.3.3.1 East Anglia ONE North commitments

19. In addition to the embedded mitigation secured through the MMMP (such as establishing a mitigation zone based on the maximum potential range for PTS, soft-start and ramp-up, and activation of ADDs prior to soft-start, also see below), the Applicant has also committed to the following:

- Only one UXO would be detonated at a time during UXO clearance operations in the East Anglia ONE North offshore development area. There would be no simultaneous UXO detonations, but potentially more than one UXO detonation could occur in a 24 hour period.
- There would be no concurrent piling at East Anglia ONE North, with only one pile being installed at a time, with no overlap in the piling duration of any two piles. Piles will be installed sequentially, and more than one pile could be installed in a single 24 hour period.
- There would be no UXO detonation in the East Anglia ONE North offshore development area at the same time as piling in the East Anglia ONE North offshore development area during the winter period, in that although they may occur in the same day or 24 hour period, they would not occur at exactly the same time.
- There would be no concurrent piling or UXO detonation between the proposed East Anglia ONE North and East Anglia TWO projects if both projects are constructed at the same time. This is stated within the draft Marine Mammal Mitigation Protocol (MMMP) (document reference 8.14) which is submitted with the DCO application. The final MMMP for piling will be produced pre-construction and is secured through the DCO.

20. The commitments apply irrespective of any additional measures agreed through the development of the SIP.

11.3.3.2 Mitigation and Best Practice

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

22. A range of different information sources have been considered as part of embedding mitigation into the design of the project (for further details see ***Chapter 6 Project Description*** and ***Chapter 4 Site Selection and Assessment of Alternatives***) including engineering requirements, ongoing discussions with

stakeholders and regulators, commercial considerations and environmental best practice.

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

24. 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.

11.3.3.2.1 Soft-Start and Ramp-Up

25. The Applicant has committed to the following to reduce potential effects of underwater noise on marine mammals, secured through the draft MMMP (document reference 8.14) submitted with the DCO application:

26. The proposed soft-start and ramp-up protocol:

- Each piling event would commence with a soft-start for a minimum of 10 minutes at 10% of the maximum hammer energy applied followed by a gradual ramp-up for at least 20 minutes to 80% of the hammer energy applied (maximum hammer energy to be applied is only likely to be required at a few of the piling installation locations).
- This minimum 30 minute soft-start and ramp-up duration is more precautionary than the current Joint Nature and Conservation Committee (JNCC) (2010a) guidance, which recommends that the soft-start and ramp-up period duration should be a period of not less than 20 minutes.
- 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 (0.9km during the soft-start and 1.8km during the ramp-up), based upon an average marine mammal swimming speed of 1.5m/s (Otani et al. 2000). However, Kastelein et al. (2018) recorded harbour porpoise swimming speeds of 1.97m/s during playbacks of pile driving sounds.

11.3.3.3 Additional Mitigation

11.3.3.3.1 Marine Mammal Mitigation Protocol (MMMP) for Piling

27. The MMMP for piling will be developed in the pre-construction period and will be based upon best available information, methodologies and industry best practice. The protocol will be developed in consultation with the Marine Management Organisation (MMO) and the relevant Statutory Nature Conservation Bodies (SNCBs), detailing the proposed mitigation measures to reduce the risk of physical or permanent auditory injury (Permanent Threshold Shift (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 any additional mitigation measures required 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 (the potential disturbance during ADD activation has been assessed in ***section 11.6.1.4.2)***.

28. A mitigation zone, based on maximum potential instantaneous 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.

29. For example, the activation of ADDs for 10 minutes prior to the soft-start would allow harbour porpoise, grey and harbour seal 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 0.58km for the starting hammer energy of 400kJ (***section 11.6.1.3.2.2***).

30. The example of mitigation for up to 10 minutes ADD activation, 10 minute soft-start and 20 minute ramp-up would enable marine mammals to move at least 3.6km from the piling location (2.7km during the 30 minute soft-start and ramp-up plus 0.9km during ADD activation for 10 minutes, based on a precautionary average marine mammal swimming speed of 1.5m/s). This would therefore be greater than the maximum predicted distance of 1.2km for PTS from a single strike at the maximum hammer energy applied for monopiles of 4,000kJ, based on the unweighted Sound Pressure Level $(SPL)_{peak}$ National Oceanic and Atmospheric Administration (NOAA) (National Marine Fisheries Service (NMFS) 2018) and Southall et al. (2019) threshold criteria (***section 11.6.1.3.2.2***).

31. The PTS SPL_{peak} criteria and maximum impact range is the most appropriate to use for the MMMP. As outlined in ***Appendix 11.4*** of the ES, peak SPLs are often used to characterise sound transients from impulsive sources and represents the maximum change in positive pressure (differential pressure from positive to zero) as the transient pressure wave propagates. However, SPL_{peak} noise levels over larger distances are difficult to predict accurately (von Benda-Beckmann et al. 2015), therefore at longer ranges, greater confidence is expected with the calculations using Sound Exposure Levels (SELs).

32. For the PTS SEL_{cum} ranges, it is important to note that an impulsive wave tends to be smoothed (i.e. the pulse becomes longer) over distance (Cudahy and Parvin 2001) and the injurious potential of a wave at greater range can be even lower than just a reduction in the absolute noise level. The smoothing of the pulse at range means that technically it develops into a 'non-pulse' of the order

of 2km to 5km. This range is still to be formally determined and agreed for use in noise modelling and will be different depending on the noise source and conditions. The SEL_{cum} ranges, also do not take into account the position of the animal in the water column. Therefore, not all animals within the maximum SEL_{cum} range would be at risk of PTS.

33. Mitigation for East Anglia ONE windfarm consisted of a mitigation zone of 500m around each individual piling location, each piling event commenced with a soft-start of at least 20 minutes and an ADD was activated for 15-30 minutes immediately prior to the soft-start to actively deter marine mammals from the mitigation zone (SPR 2017b). During daylight hours MMOs conducted a dedicated pre-piling watch of the mitigation zone for a minimum of 30 minutes prior to the commencement of soft-start piling. At night and during periods of poor visibility pre-piling monitoring was undertaken by a PAM Operator using a PAM system. The three dedicated dual role MMOs / PAM Operators undertook visual observations and acoustic monitoring for marine mammals during the installation of 102 three legged jacket foundations between the 25th April 2018 and the 30th January 2019. There were 675 hours and 38 minutes of visual observations and 880 hours and 46 minutes of acoustic monitoring conducted throughout the survey. During this time there were only three marine animal sightings, two of which were while the vessel was in transit and the other was on site and resulted in a delay to soft-start operations. No acoustic detections were made. This indicates that the mitigation implemented during piling at the East Anglia ONE windfarm was effective and there was no risk of physical or auditory injury to marine mammals.

34. 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. A combined draft MMMP has been submitted with the DCO Application (document reference 8.14) for both UXO clearance and piling, however, two separate MMMPs, one for piling and one for UXO clearance, will be prepared in-consultation with the relevant SNCBs during the pre-construction period.

11.3.3.3.2 MMMP for Unexploded Ordnance (UXO) Clearance

35. A detailed MMMP will be prepared for UXO clearance during the pre-construction phase. 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 MMO and relevant SNCBs.

36. The MMMP for UXO clearance will involve the establishment of a suitable mitigation zone around the UXO location before any detonation. The Applicant will implement mitigation measures considered adequate to exclude marine mammals from within the mitigation zone prior to any UXO detonation, to reduce the risk of any physical or permanent auditory injury (PTS).

37. 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:

- All detonations taking place in daylight.
- 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.
- 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, and if the equipment can be safely deployed and retrieved.
- The activation of acoustic deterrent devices (ADDs).
- If required and where possible and safe to do so, a soft-start procedure using scare charges.
- 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.

38. 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. As noted above, a combined draft MMMP has been submitted with the DCO Application (document reference 8.14) for both piling and UXO clearance, however, two separate MMMPs, one for UXO clearance and one for piling, will be prepared in-consultation with the relevant SNCBs during the pre-construction period.

11.3.3.3.3 Site Integrity Plan

39. The designation of the Southern North Sea (SNS) candidate Special Area of Conservation (cSAC) was approved by the European Commission to be designated as a Site of Community Importance (SCI) in 2017, and has further been formally designated by the UK government as a Special Area of Conservation (SAC) and is therefore referred throughout as the SNS SAC.

40. The draft Habitats Regulation Assessment (HRA) undertaken by the Secretary of State for Business Energy and Industrial Strategy (BEIS) for the Review of Consents (RoC) process for the SNS SAC (BEIS 2018) proposes that each project develops a Site Integrity Plan (SIP). The SIP would set out the approach to deliver any project mitigation or management measures in relation to the SNS SAC for harbour porpoise.

41. Any SIP would be in addition to the MMMPs for piling and UXO clearance. A combined In-principle SNS SIP has been submitted with the DCO Application (document reference 8.17) for both UXO clearance and piling, however, two separate SIPs, one for piling and one for UXO clearance, will be prepared in-consultation with the relevant SNCBs during the pre-construction period.

11.3.4 Monitoring

42. Post-consent, the final detailed design of the proposed East Anglia ONE North project will refine the worst-case parameters assessed in this ES. It is recognised that monitoring is an important element in the management and verification of the actual impacts based on the final detailed design. Outline Management Plans, across a number of environmental topics, have been submitted with the DCO application. These Outline Management Plans contain key principles that provide the framework for any monitoring that could be required. The draft MMMP and In-principle SIP submitted with the DCO application (document references 8.14 and 8.17) contain key principles that provide the framework for any monitoring that could be required. An In-principle monitoring plan has also been submitted with the DCO application (document reference 8.13). The requirement for and final design and scope of monitoring will be agreed with the regulator and relevant stakeholders and included within the relevant Management Plan, submitted for approval, prior to construction works commencing.

11.4 Assessment Methodology

11.4.1 Guidance

11.4.1.1 Legislation

11.4.1.1.1 The Habitats Directive

43. 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.

44. Annex II of the Habitats Directive lists species for which member states are expected to establish a “consistent network of special areas of conservation”. This list includes harbour porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus* along with the grey seal *Halichoerus grypus* and harbour seal

Phoca vitulina all of which are relevant to proposed East Anglia ONE North project.

45. Although not legally binding, the European Commission's Guidance document on the strict protection of animal species of Community interest under the Habitats Directive (European Commission (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*".

46. 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 SACs.

47. 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.

11.4.1.1.2 The Habitats Regulations

48. The Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (collectively referred to as '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 have a significant effect on a Natura 2000 site, to seek advice from SNCBs and to reject an application that would have an adverse effect on the integrity of a Natura 2000 site except under very tightly constrained conditions. The competent authority in the case of the proposed project is the Secretary of State for BEIS. The Information to Support the Appropriate Assessment report (document reference 5.3) includes the assessment of the proposed East Anglia ONE North project against the requirements imposed by the regulations.

49. 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).

50. Under the Habitats Regulations 2017 a person is guilty of an offence if that person:

- Deliberately captures, injures or kills a wild animal belonging to a species with EPS status;
- Deliberately disturbs such animal; or
- Damages or destroys any resting or breeding place of such animal.

51. However, there is a provision to apply for an EPS licence where any of the above is expected to occur, provided there is no satisfactory alternative, and there will be no long term detrimental effects. This is especially relevant to marine mammals and the likelihood of disturbance due to marine activities.

52. As in the Habitats Directive, there is a requirement to create SACs for species listed under Annex II (i.e. harbour porpoise, bottlenose dolphin, grey and harbour seals) and to advise on what marine operations may adversely affect the integrity of the site.

53. 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 nurture their young, to disrupt a species' hibernation or migrations, or to affect significantly the local distributions or abundance of the species; and
- Damage or destroy any breeding or resting site.

11.4.1.1.3 Summary of Relevant Legislation

54. ***Table 11.3*** provides an overview of national and international legislation in relation to marine mammals.

Table 11.3 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 10 European countries bordering the Baltic and North Seas (including the English Channel) and includes the 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 and harbour seal	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.
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	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

Legislation	Level of Protection	Species Included	Details
			cetaceans, in particular the enforcing a moratorium on commercial whaling which came into force in 1986.
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 Appendix 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 and The Conservation of Offshore Marine Habitats and Species Regulations 2017	National	All cetaceans, grey and harbour seal	'The Habitats Regulations 2017'. Provisions of The Habitats Regulations are described further above. It should be noted that the Habitats Regulations apply onshore, within the territorial seas and to marine areas within UK jurisdiction, beyond 12 nautical miles (nm).
The Wildlife and Countryside Act 1981 (as amended)	National	All cetaceans	All cetaceans listed on Schedule 5 are fully protected within UK territorial waters. The Act protects them from killing or injury, sale, destruction of a particular habitat (which they use for protection or shelter) and disturbance. Short-beaked common dolphin, bottlenose dolphin and harbour porpoise are listed on Schedule 6 of the Act. Under the Act these species are prohibited from being used as a decoy to attract other animals. The Act also prohibits the use of vehicles in immediate pursuit to take, kill or drive them, it prevents nets, traps or

Legislation	Level of Protection	Species Included	Details
			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.
Conservation of Seals Act 1970	England and Wales	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 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.

11.4.1.2 Guidance and Policy

55. 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).

56. The Overarching NPS for Energy (EN-1) sets out the UK 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 11.4*** sets out the specific assessment requirements for marine mammals.

57. Paragraphs 2.6.92 to 2.6.99 of EN-3 outline the main priorities and concerns for offshore windfarm 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.

58. 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-piling 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.

Table 11.4 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 windfarm 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.	***Section 11.3.2*** provides an overview of the worst-case scenario for possible piling works. ***Sections 11.6.1.3*** and ***11.6.1.1.4*** provides an assessment of pile driving (including noise modelling results).

NPS Requirement	NPS Reference to Text	Section Reference
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); And Soft-start noise levels according to proposed hammer and pile design; and operational noise.	Paragraph 2.6.92 of the NPS EN-3.	***Section 11.5*** provides a description of the existing environment. ***Section 11.6.1*** details the assessment of impacts during construction, including pile driving. ***Sections 11.6.2.1*** and ***11.6.2.2*** provide 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.	***Section 11.6.1*** details the assessment of impacts during construction, including pile driving, and mitigation measures. The Applicant has consulted with Natural England (see ***Appendix 11.1***) through the Evidence Plan Process (EPP).
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.	Paragraphs 2.6.94 to 2.6.96 of the NPS EN-3.	***Chapter 6 Project Description*** describes the foundation options under consideration for proposed East Anglia ONE North project. ***Section 11.3.2*** describes the worst-case scenario for marine mammals.

NPS Requirement	NPS Reference to Text	Section Reference
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. 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 windfarm 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.	A draft MMMP and In-principle monitoring plan have been submitted with the DCO application (document references 8.14 and 8.17). These plans will be further developed in consultation with the MMO and relevant SNCBs post-consent and will identify any necessary monitoring requirements.

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

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

60. Annex I of the MSFD states that to ensure that good environmental status is met, 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.

61. 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.

62. 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".

63. 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 (Joint Nature Conservation Committee (JNCC) et al. 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 (Centre for the Environment and Fisheries and Aquaculture Science (Cefas) 2011); and
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC 2010a).

11.4.1.2.1 European Protected Species Guidance

64. The JNCC, Natural England and the Countryside Council for Wales (CCW) (JNCC et al. 2010) have produced draft guidance concerning the Habitats Regulations 2017 on the deliberate disturbance of marine EPS, which 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).

65. 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 European Commission's Guidance document (EC 2007) stating that, there must be some ecological impact in order for significant disturbance to occur.

66. The draft guidance provides the following interpretations of deliberate injury and disturbance offences under both 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".

67. 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".

68. 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.

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

70. 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 Favourable Conservation Status (FCS; see ***section 11.4.1.2.2***) 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.

71. 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.

72. 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.

73. 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".

74. 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 11.4.4.3***). Consideration of any potential essential habitat or geographical structuring of EPS is provided in the existing environment section (***section 11.5***) of this chapter.

75. 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 EIA 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' and populations' life-history;
  - The species' FCS assessment in UK waters; and
  - Other pressures encountered by the population (cumulative effects).

76. 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).

77. An EPS licence is required if the risk of injury or disturbance to cetacean species is assessed as likely under the Habitats Regulations 2017.

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

- Whether the activity falls within one of the purposes specified in Regulation 55 of the Habitats Regulations. Only the purpose of *"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 in this context;

- That 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.

79. Under the 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 the Applicant is likely to be required to apply for an EPS licence from the MMO in order to be exempt from the offence.

80. If required, the EPS licence application will be submitted post-consent. At that point in time, the project design envelope will have been further refined through detailed design and procurement activities and further detail will be available on the techniques selected for the construction of the windfarm, as well as the mitigation measures that will be in place following the development of MMMPs for piling and UXO clearance.

11.4.1.2.2 Favourable Conservation Status

81. Member states report back to the European Union (EU) every six years on the Conservation Status of marine EPS. Based on the most recent 2007-2012 reporting by the Joint Nature and Conservation Committee (JNCC 2013), seven species of the eleven cetacean species were assessed as having a 'favourable' Conservation Status (***Table 11.5***).

82. Four of eleven cetacean species were assessed as having an 'unknown' Conservation Status (JNCC 2013). This is a result of a lack of recent population estimates that encompassed their natural range in UK and adjacent waters and / or having no evidence to determine long-term trends in population abundance.

83. Another 17 species were considered to be uncommon, rare or very rare in occurrence, so it was not possible to ascertain their Conservation Status (JNCC 2013).

Table 11.5 FCS Assessment of Cetacean Species in Annex IV of the Habitats Directive Occurring in UK and Adjacent Waters (JNCC 2013)

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

11.4.2 Data Sources

84. Information to support the EIA is based on 24 months (September 2016 to August 2018) of survey data for the East Anglia ONE North windfarm site plus 4km buffer (referred to as the marine mammal survey area), as agreed through the EPP (Marine Mammal ETG meeting, March 2018).

85. APEM Ltd collected high resolution aerial digital still imagery for marine mammals (combined with ornithology surveys) over the marine mammal survey area, capturing imagery at 2cm Ground Sampling Distance (GSD). Coverage of the marine mammal survey area was between approximately 10% and 17% per month. All images were analysed to enumerate marine mammals to species level, where possible (see ***Appendix 11.2*** for further details).

86. In addition, the surveys for other offshore windfarms in the former East Anglia Zone, as outlined in ***Table 11.6*** provide useful context (see ***Appendix 11.2***).

Table 11.6 Data Sets Used for Informing Marine Mammals Existing Environment

Data Set	Spatial Coverage	Survey Timing
Zone Environmental Appraisal (ZEA) ornithology and marine mammal survey (video)	Former East Anglia Zone	November 2009 to March 2010
East Anglia ONE ornithology and marine mammal survey (digital aerial surveys and boat-based surveys)	East Anglia ONE plus 4km buffer	November 2009 to October 2011 May 2010 to April 2011
ZEA ornithology and marine mammal survey (digital aerial)	Former East Anglia Zone	April 2010 to April 2011
Aerial ornithology and marine mammal surveys (digital aerial)	Southwest portion of the former East Anglia Zone overlapping the East Anglia TWO windfarm site	September 2011 to December 2012
East Anglia THREE ornithology and marine mammal survey (digital aerial)	East Anglia THREE plus 4km buffer	September 2011 to August 2013
East Anglia FOUR (now Norfolk Vanguard East) ornithology and marine mammal survey (digital aerial)	East Anglia FOUR plus 4km buffer	March 2012 to April 2016
Norfolk Vanguard ornithology and marine mammal survey (digital aerial)	Norfolk Vanguard plus 4km buffer	September 2015 to August 2017
Norfolk Boreas ornithology and marine mammal survey (digital aerial)	Norfolk Boreas plus 4km buffer	August 2016 to January 2018
East Anglia TWO aerial ornithology and marine mammal survey (digital aerial)	East Anglia TWO windfarm site plus 4km buffer	November 2015 to April 2016, September 2016 to October 2017, and May to August 2018
East Anglia ONE North aerial ornithology and marine mammal survey (digital aerial)	East Anglia ONE North windfarm site plus 4km buffer	September 2016 to August 2018

87. Further to the survey data outlined in ***Table 11.6***, a range of information has also informed the EIA, including, but not limited to, the data sources listed in ***Table 11.7*** (also see ***Appendix 11.2***).

88. Consultation with key marine mammal stakeholders will be ongoing during the EIA through the EPP and will include discussion of the best available data sets and information to use. ***Table 11.7*** summarises the information currently publicly available that have been included within the ES.

Table 11.7 Additional Information Sources for Marine Mammals Existing Environment

Information Source	Year	Spatial Coverage	Notes
Small Cetaceans in the European Atlantic and North Sea (SCANS-III) data (Hammond et al. 2017)	Summer 2016	North Sea and European Atlantic waters	Provides information including abundance and density estimates of cetaceans in European Atlantic waters in summer 2016, including the East Anglia ONE North offshore development area.
SCANS-II data (Hammond et al. 2013)	July 2005	North Sea and European Atlantic shelf waters	Provides information including abundance and density estimates for the East Anglia ONE North offshore development area.
Management Units (MUs) for cetaceans in UK waters (Inter-Agency Marine Mammal Working Group (IAMMWG) 2015)	2015	UK waters	Provides information on MU for the East Anglia ONE North offshore development area.
Offshore Energy Strategic Environmental Assessment (including relevant appendices and technical reports) (Department of Energy and Climate Change (DECC) (now BEIS 2016)	2016	UK waters	Provides information for the wider southern North Sea area.
The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area (Heinänen and Skov 2015)	1994-2011	UK Exclusive Economic Zone (EEZ)	Data was used to determine harbour porpoise SAC sites. Provides information on harbour porpoise in southern North Sea area.
Revised Phase III data analysis of Joint Cetacean Protocol (JCP) data resources (Paxton et al. 2016)	1994-2011	UK EEZ	Provides information for the Norfolk Bank development area, which includes the East Anglia ONE North windfarm site.
Survey for small cetaceans over the Dogger Bank and adjacent areas in summer 2011 (Gilles et al. 2012)	Summer 2011	Dogger Bank and adjacent areas	Provides information for wider area.
Seasonal habitat-based density models for a marine top predator, the harbour porpoise, in a dynamic environment (Gilles et al. 2016)	2005-2013	UK (SCANS II, Dogger Bank), Belgium, the Netherlands,	Provides information for central and southern North Sea area.

Information Source	Year	Spatial Coverage	Notes
		Germany, and Denmark	
Distribution of Cetaceans, Seals, Turtles, Sharks and Ocean Sunfish recorded from Aerial Surveys 2001-2008 (The Wildfowl and Wetlands Trust (WWT) 2009)	2001-2008	UK areas of the North Sea	Provides information for on species in southern North Sea area.
MARINElife surveys from ferries routes across the southern North Sea area (MARINElife 2018)	2017-May 2018	Southern North Sea	Provides information on species in southern North Sea area.
Sea Watch Foundation volunteer sightings off eastern England (Sea Watch Foundation 2018)	2017-May 2018	East coast of England	Provides information on species sighted along east coast of England.
UK seal at sea density estimates and usage maps (Russell et al. 2017)	1988-2012	North Sea	Provides information on abundance and density estimates for seal species.
Seal telemetry data (e.g. Sharples et al. 2008; Russell and McConnell 2014; Russell 2016)	1988-2010; 2015	North Sea	Provides information on movements and distribution of seal species.
Special Committee on Seals (SCOS) annual reporting of scientific advice on matters related to the management of seal populations (SCOS 2018).	2018	North Sea	Provides information on seal species.
Counts of grey seal in the Wadden Sea (Brasseur et al. 2018)	Winter 2017 to 2018	Wadden Sea	Counts of grey seal during moult season.
Counts of harbour seal counts in the Wadden Sea (Galatius et al. 2018)	August 2018	Wadden Sea	Counts of harbour seal during pupping season.

11.4.3 Assumptions and Limitations

89. Due to the large amount of data that has been collected during the Zone Environmental Appraisal (ZEA), for the former East Anglia Zone and site specific surveys for the proposed East Anglia ONE North project, as well as other projects in the former East Anglia 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 data collected by 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 surveys in the study area over the last decade show relatively consistent results. There are also limitations in the detectability of marine mammals from aerial surveys. ***Appendix 11.2*** seeks to address these limitations by estimating a Correction Factor (CF) in order to determine estimated absolute density estimates from the site specific aerial surveys.

90. 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.

11.4.4 Impact Assessment Methodology

91. The general EIA methodology is set out within ***Chapter 5 EIA Methodology***. In principle, a matrix approach has been used to assess impacts following best practice, EIA guidance and the approach outlined in the proposed East Anglia ONE North project Scoping Report (Scottish Power Renewables 2017) and the East Anglia ONE North Marine Mammal Method Statement (Appendix 2 of Scottish Power Renewables 2017). The data sources summarised in ***section 11.4.2*** were used to characterise the existing environment (see ***section 11.5*** and ***Appendix 11.2***). Each potential impact has been identified using expert judgement and through consultation with 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.

11.4.4.1 Sensitivity

92. The sensitivity of a receptor is defined by its ability to accommodate change and on its ability to recover if affected. The level of sensitivity 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 receptor's importance, rarity and worth (see below).

93. The impact of most concern across the offshore wind sector is the sensitivity of marine mammals to pile driving noise. 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 11.8*** defines the levels of sensitivity and what they mean for the receptor.

Table 11.8 Definitions of the Sensitivity Levels for Marine Mammals

Sensitivity	Definition
High	Individual receptor has very limited capacity to avoid, adapt to, tolerate or recover from the anticipated impact.
Medium	Individual receptor has limited capacity to avoid, adapt to, tolerate or recover from the anticipated impact.
Low	Individual receptor has some tolerance to avoid, adapt to, tolerate or recover from the anticipated impact.
Negligible	Individual receptor is generally tolerant to and can tolerate or recover from the anticipated impact.

11.4.4.2 Value

94. In addition, the 'value' of a receptor forms an important element within the assessment, for instance, if the receptor is a protected species or has an economic value. It is important to understand that high value and sensitivity are not necessarily linked within a particular impact. A receptor could be of high value (e.g. an Annex II species), 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.

95. 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.

96. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement. ***Table 11.9*** provides definitions for the value afforded to a receptor based on its legislative importance.

Table 11.9 Example Definitions of the Value Levels for Marine Mammals

Value	Definition
High	Internationally or nationally important Internationally protected species that are listed as a qualifying interest feature of an internationally protected site (i.e. Annex II protected species designated feature of a European designated site) and protected species (including EPS) that are not qualifying features of a European designated site.
Medium	Regionally important or internationally rare Protected species that are not qualifying features of a European designated site, but are recognised as a Biodiversity Action Plan (BAP) priority species either alone or under a grouped action plan, and are listed on the local action plan relating to the marine mammal study area.
Low	Locally important or nationally rare Protected species that are not qualifying features of a European designated site and are occasionally recorded within the study area in low numbers compared to other regions.
Negligible	Not considered to be particularly important or rare Species that are not qualifying features of a European designated site and are never or infrequently recorded within the study area in very low numbers compared to other regions.

11.4.4.3 Magnitude

97. The significance of the potential impacts is also assessed on the degree or intensity of disturbance to the baseline conditions. Four levels of magnitude are used: high; medium; low; or negligible, as defined in ***Table 11.10***.

98. The thresholds used to define the level of magnitude for each impact have been defined by expert judgement, current scientific understanding of marine mammal population biology and JNCC et al. (2010) draft guidance on disturbance to EPS species. For each effect, the assessment describes the magnitude in a qualitative or quantitative way. This approach was agreed with Natural England at an ETG meeting in May 2017 on the marine mammal method statement as part of the scoping report (Appendix 2.5 of the Scoping Report (SPR 2017a).

99. The number of animals that can be 'removed' through disturbance or injury is largely dependent on population growth rates, although variable between species. A population with a smaller growth rate is able to sustain the removal of a smaller proportion of the population than one with a larger growth rate. Some

indication of how many animals may be removed from a population without causing detrimental effects at FCS is provided by JNCC et al. (2010). This guidance reflects consideration of permanent displacement and limited consideration of temporary effects. As such this guidance has been considered in defining the thresholds for magnitude of effects.

100. Temporary effects are considered to be of medium magnitude when more than 5% of the reference population is affected within one 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.

101. Permanent effects with a greater than 1% of the reference population being affected within a single year are considered to be high in magnitude in this assessment. This is based on Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and Defra advice (Defra 2003, ASCOBANS 2015) relating to impacts from fisheries by-catch (i.e. a permanent effect) on harbour porpoise. A threshold of 1.7% of the relevant harbour porpoise population above which a population decline is inevitable has been agreed with Parties to ASCOBANS, with an intermediate precautionary objective of reducing the impact to less than 1% of the population (Defra 2003, ASCOBANS 2015).

Table 11.10 Example Definitions of the 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 more than 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 more than 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.

Magnitude	Definition
	Assessment indicates that more than 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. OR Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the project). Assessment indicates that between 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 between 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 less than 0.001% of the reference population anticipated to be exposed to effect. OR

Magnitude	Definition
	Long-term effect for 10 years or more (but not permanent, e.g. limited to lifetime of the project). Assessment indicates that less than 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 less than 1% of the reference population anticipated to be exposed to effect.

11.4.4.4 Impact Significance

102. Following the identification of receptor value, sensitivity and magnitude of the effect, the impact significance is determined using expert judgement. The assessment process also considers the probability of the impact occurring. The precautionary approach is taken to assign a higher level of probability to any adverse effects if the level of impact is uncertain, or if doubt exists concerning the likelihood of the occurrence of an impact.

103. A matrix, as presented in ***Table 11.11**,* is used as a framework to aid determination of the impact assessment. Definitions of impact significance are provided in ***Table 11.12***. For the purpose of this ES and the marine mammal assessment specifically, major and moderate impacts are deemed to be significant. However, whilst minor impacts would not be deemed to be significant in their own right, they may contribute to significant impacts through inter-relationships or cumulative impacts.

Table 11.11 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 11.12 Impact Significance Definitions

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

104. Embedded mitigation, as outlined in ***section 11.3.3.2*** will be referred to and included in the initial assessment of impact. Following the initial assessment, if the impact does not require additional mitigation (or none is possible) the residual impact will remain the same. If, however, additional mitigation is required or proposed there is an assessment of the post-mitigation residual impact.

11.4.5 Cumulative Impact Assessment

105. The CIA identifies areas where the predicted impacts of the construction, operation, maintenance and decommissioning of the project could interact with impacts from different plans or projects within the same region and impact sensitive receptors.

106. As outlined in The Planning Inspectorate (2015) Advice Note 17:

- The need to consider cumulative effects in planning and decision making is set out in planning policy[1], in particular the National Policy Statements (NPS). For example, the Overarching NPS for Energy (EN-1) paragraph 4.2.5 states that:

  "When considering cumulative effects, the ES should provide information on how the effects of the applicant's proposal would combine and interact with the effects of other development[2] (including projects for which consent has been sought or granted, as well as those already in existence)".

[1] For example: The relevant National Policy Statements (England and Wales) and National Planning Policy Framework (NPPF) (England);
[2] 'other development' is taken to include plans and projects

107. The ‘other development’ types that should be considered in the CIA as set out in Advice Note 17, 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 where a scoping report has been submitted;
- Projects on the Planning Inspectorate’s Programme of Projects where a scoping report has not been submitted;
- Identified in the relevant Development Plan (and emerging Development Plans – with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited; and
- Identified other plans and programmes (as appropriate) which set the framework for future development consent/approvals, where such development is reasonably likely to come forward.

108. For this assessment, the 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;
- Tier 3: projects that have been consented (but construction has not yet commenced);
- Tier 4: projects that have an application submitted to the appropriate regulatory body that have not yet been determined;
- 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); and
- Tier 6: projects that have been identified in relevant strategic plans or programmes.

109. These tiers are used as they are considered more appropriate to use compared to the tiers in The Planning Inspectorate (2015) Advice Note 17 for the types of projects and plans considered in this assessment, in particular for the offshore windfarm stages.

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

- Other offshore windfarms;
- 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
- UXO clearance.

111. Commercial fisheries (see ***section 11.4.5.1***) are not considered in the CIA.

112. The CIA is a two-part process in which an initial list of potential projects is identified with the potential to interact with the proposed East Anglia ONE North project 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.

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

1) Located in the marine mammal MU population reference area (defined for individual species in the assessment sections);
2) Offshore projects and developments, if there is the potential for cumulative impacts during the construction, operation or decommissioning of the proposed East Anglia ONE North project; and
3) Offshore windfarm developments, if the construction and / or piling period could overlap with the proposed construction and/or piling period of the East Anglia ONE North project, based on best available information on when the developments are likely to be constructed and piling.

114. The CIA will consider projects, plans and activities which have sufficient information available 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.

115. The project tiers considered in the CIA for marine mammals are outlined in the CIA screening (***Appendix 11.3***).

11.4.5.1 Commercial fisheries

116. Commercial fisheries within the North Sea and underwater noise associated with vessels from industries other than offshore wind farms, have the potential to cause a cumulative impact on marine mammals, including harbour porpoise, alongside the construction of the East Anglia ONE North project, through both the direct impact of by-catch and the indirect impact through the loss of marine mammal prey species (from commercial fisheries) and the disturbance from underwater noise (from vessel presence).

117. By-catch as a result of commercial fisheries is recognised as a historic and continuing cause of harbour porpoise mortality in the southern North Sea and will therefore be a factor in shaping the size of the current North Sea (NS) Management Unit (MU) population. The available prey resource for harbour porpoise has also been influenced by historic and continuing commercial fishing. Noise from vessels associated with plans or projects other than offshore wind farm industries, such as oil and gas, aggregates and commercial fisheries, are also considered to be part of the baseline conditions.

118. This approach is in accordance with the Planning Inspectorate Advice Note 17 Cumulative Effects Assessment, which states that:

“*Where other projects are expected to be completed before construction of the proposed NSIP and the effects of those projects are fully determined, effects arising from them should be considered as part of the baseline*”.

119. The potential for cumulative impacts associated with commercial fisheries within the SNS SAC site has been considered in the recent draft HRA for the Review of Consents (RoC) (which was consulted upon in November 2018; BEIS 2018). With regard to effects to habitats, the draft RoC HRA states that (note that the SNS SAC was designated as a SCI at the time of writing):

“*19.152 There have been no quantified assessments undertaken on the extent impacts from commercial fishing may have within the SCI and therefore information to inform this assessment is not available*.

19.154 Without knowing the extent of impact on the seabed arising from the fishing industry and aggregate extraction it is not possible to undertake an in-combination assessment that addresses all the potential impacts on the habitats within the SCI.”

120. The conservation status of harbour porpoise has not declined in the years that commercial fishing has been undertaken in the North Sea, and remains favourable within both North Sea and in UK waters as a whole; therefore, the historical and current levels of commercial fishing in the North Sea is not considered to have affected the conservation status of the species (BEIS 2018).

121. With regard to direct effects on harbour porpoise, the draft RoC HRA (BEIS 2018) also states that:

"*19.213 Commercial fishing has occurred within the SCI for many years and has had, and will continue to have, direct and indirect impacts on harbour porpoise, their habitat and prey within the SCI. As the conservation status of harbour porpoise in UK waters and the SCI is considered favourable (JNCC 2016, 2017a) current and historical levels of fishing in the SCI are not considered to have affected the conservation status of the species.*

19.214 There are no known plans to suggest that the level of fishing within the SCI will significantly increase over the period the consented wind farms are planned to be constructed, such that, it is predicted that the current level of impacts from fishing on harbour porpoise within the SCI will not increase."

122. Natural England's Deadline 4 Response to the Examining Authority's Further Written Questions and Requests for information for Hornsea Project 3 (15th January 2019) (page 46, Q 2.2.73) was that:

"*Where there is ongoing fishing activity in the site, it is important that the impacts of the activity are captured within the assessment in the context of the conservation objectives of the affected designated site(s). This assessment will likely take place as part of the baseline characterisation of the development area, however, as fishing activity is mobile, variable and subject to change, there may be instances whereby fishing impacts are not adequately captured in the baseline characterisation and therefore may need to be considered as part of the in-combination assessment. This could be due to a change in effort; change in management; or a change in legislation amongst other things, and fishery managers (i.e. MMO and IFCAs) would be best placed to advise on this*.

In relation to the assessment of impacts on the SNS SCI, Natural England……. are not currently aware of anything that would have significantly altered the levels of fishing activity within the site; any current plans for new fisheries, or changes to existing fisheries that have not been captured, but we would look to fisheries managers to advise more definitively on these points."

123. This, along with the draft RoC, suggests that by-catch has not affected a population considered to be in FCS, whilst Natural England acknowledge that there is currently no evidence to suggest that the current levels of fishing would significantly alter in the future, they are consulting with fisheries managers (i.e. MMO and IFCAs) for further advice.

124. Therefore, the potential impacts from commercial fishing (including by-catch and loss of prey species) and from the underwater noise associated with other, non-offshore wind farm industries (including oil and gas, aggregates and commercial

fisheries) are considered to be a part of the environmental baseline for marine mammals of the North Sea, including for harbour porpoise, and are screened out of further assessment for the East Anglia ONE North project.

11.4.6 Transboundary Impact Assessment

125. 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.

126. The assessment of the effect on the integrity of the transboundary European sites as a result of impacts on the designated marine mammal populations is undertaken and presented in the Information to Support Appropriate Assessment report submitted with this ES (document reference 5.3).

11.5 Existing Environment

127. The characterisation of the existing environment is undertaken using data sources listed in ***Table 11.6*** plus all other relevant literature (***Table 11.7***).

128. The available data from the proposed East Anglia ONE North project site-specific survey, former East Anglia Zone surveys, other offshore windfarm surveys and other data sources, including SCANS-II (Hammond et al. 2013) and 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), and rare sightings of low numbers of other cetaceans.

129. 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 ***Appendix 11.2***, however, given the low numbers and infrequent sightings of these species in and around the East Anglia ONE North offshore development area, it has been concluded that there is a very low risk of any significant impacts and therefore these species have not been assessed further.

130. A review of the data and information sources outlined in ***Table 11.6*** and ***Table 11.7***, as well as other relevant information (***Appendix 11.2***), indicates that marine mammal species likely to be present in the East Anglia ONE North offshore development area and taken forward for the impact assessment are:

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

131. The marine mammal species included in the assessment have been agreed with the marine mammal ETG as part of the EPP.

132. ***Section 11.5.6*** provides a summary of the relevant density estimates and reference populations that are used in the assessments.

11.5.1 Harbour Porpoise

133. The information relevant to the assessment for harbour porpoise has been included in this section, with further information provided in ***Appendix 11.2***.

11.5.1.1 Distribution

134. 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. The Heinänen and Skov (2015) analysis was used in the identification of potential SACs for harbour porpoise in UK waters (see ***Appendix 11.2*** and ***section 11.5.1.1***).

135. The seasonal maps produced by Gilles et al. (2016) for harbour porpoise density across the central and south-eastern North Sea, indicated that in spring there were higher density areas in the southern and south-eastern part of the North Sea. In summer, there was an apparent shift, compared to spring, toward offshore and western areas. In autumn, there were lower densities compared to spring and summer, and the distribution was spatially heterogeneous (further information is provided in ***Appendix 11.2***).

136. The JCP Phase-III report (Paxton et al. 2016) indicated a high use area for the offshore region off the East Anglia coast (see ***Appendix 11.2*** for further information).

11.5.1.2 Diet

137. 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* species), which are known prey for harbour porpoise, exhibit a strong association with key surface sediments (Gilles et al. 2016; Clarke et al. 1998).

138. Harbour porpoises are generalist feeders and their diet reflects available prey in an area. Therefore, their diet varies geographically, seasonally and annually, reflecting changes in available food resources and differences in diet between sexes or age classes may also exist. 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 sandeels (Berrow and Rogan 1995; Kastelein et al. 1997; Börjesson et al. 2003; Santos and Pierce 2003; Santos et al. 2004).

139. 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.

11.5.1.3 Abundance and Density Estimates

140. Full information on abundance and density estimates, and supporting survey data are provided in ***Appendix 11.2*** and summarised below.

11.5.1.3.1 North Sea Management Unit

141. The SCANS-III estimate of harbour porpoise abundance in the North Sea MU is 345,373 (Coefficient of Variation (CV) = 0.18; 95%; Confidence Interval (CI) = 246,526-495,752) with a density estimate of 0.52/km^2 (CV = 0.18; Hammond et al. 2017). This is the reference population for harbour porpoise, as agreed with Natural England as part of the marine mammal ETG (see ***Appendix 11.1***) at the meeting on 6th March 2018.

11.5.1.3.2 SCANS Data

142. 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).

143. The East Anglia ONE North offshore development area is in SCANS-III survey block L (see ***Appendix 11.2***):

- 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).

11.5.1.3.3 East Anglia ONE North Site Specific Surveys

144. As outlined in ***section 11.4.2***, high resolution aerial digital still imagery was collected for marine mammals over the East Anglia ONE North windfarm site with a 4km buffer (referred to as the marine mammal survey area). ***Appendix 11.2*** shows the location of the marine mammal survey area and further information on the analysis and interpretation of the survey results, including seasonal CFs, is also provided in ***Appendix 11.2***.

145. The information included in this ES is based on 24 months of survey for the proposed East Anglia ONE North project (September 2016 to August 2018).

146. The harbour porpoise density estimate for the East Anglia ONE North windfarm site is comparable to other offshore windfarm sites in the former East Anglia Zone and SCANS-III survey (***Table 11.13***).

Table 11.13 Harbour Porpoise Density Estimates (with Seasonal CFs) from Site Specific Surveys at East Anglia ONE, East Anglia THREE, Norfolk Vanguard, East Anglia TWO and East Anglia ONE North, and the SCANS-III Surveys

Site	Harbour Porpoise Density Estimate (individuals/km^2)
East Anglia ONE North windfarm site	**0.58**
East Anglia TWO windfarm site	0.73
East Anglia ONE	Maximum = 1.4 and Mean = 0.19 Based on ES (EAOW 2012)
East Anglia THREE	0.294 Based on ES (EATL 2015)
Norfolk Vanguard East	1.26 Based on ES (Norfolk Vanguard Limited 2018)
Norfolk Vanguard West	0.79 Based on ES (Norfolk Vanguard Limited 2018)
Norfolk Boreas	1.06 Based on ES (Norfolk Boreas Limited 2010)
SCANS-III survey block L	0.607 Based on Hammond et al. 2017

147. The annual mean density estimate, when using the seasonal CF is 0.58/km^2 for the East Anglia ONE North windfarm site. The density estimate during summer (April to September) is 0.22/km^2 and during the winter (October to March) the estimated density is 0.94/km^2 using the corrected densities.

148. The East Anglia ONE North windfarm site density estimate of 0.58/km^2, based on the mean annual density and using the seasonal CF, has been used to inform the assessments of impact (***Table 11.17***). Using the mean annual density allows for seasonal variation in the number of harbour porpoise that could be present.

149. The number of harbour porpoise is put into the context of the North Sea MU, therefore it is appropriate to base the assessments on the annual mean density estimates rather than then seasonal density estimates.

11.5.1.4 Reference population for assessment

150. The reference population used in the assessment for harbour porpoise is the most up to date 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).

11.5.2 Grey Seal

151. The information relevant to the assessment for grey seal has been included in this section, with further information provided in ***Appendix 11.2***.

11.5.2.1 Distribution

152. 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 indicate that very few tagged greys seals have been recorded in and around the East Anglia ONE North windfarm site, with the tracks of only one grey seal pup tagged at the Isle of May in 2002 passing in the vicinity of the East Anglia ONE North windfarm site (see ***Appendix 11.2***; Russell and McConnell 2014).

153. Aerial surveys conducted for the former East Anglia Zone and both the aerial and boat surveys at the East Anglia ONE site did not record any observations of seals and during East Anglia THREE surveys only two seals were recorded (EAOW 2012a, b; EATL 2015). The results of the surveys support the tagging data and suggest that there is low usage of the former East Anglia Zone.

154. Relatively low numbers (18 individual seals) were also recorded during the aerial surveys for the proposed East Anglia TWO project, from November 2015 to April 2016, from September 2016 to October 2017, and May to August 2018 (24 months), only one individual was identified to species level, and was recorded as being a grey seal (SPR 2019). Results of the site specific surveys for the East Anglia ONE North project are presented in ***section 11.5.2.4.3*** below.

155. For the East Anglia THREE EIA (EATL 2015), East Anglia THREE Limited (EATL) commissioned SMRU Marine Ltd and IMARES to investigate the connectivity between tagged grey seal and the East Anglia THREE site plus a 20km buffer area (EATL 2015). The data indicated the movement of grey seals between MUs on the east coast of England and Scotland and the movement of grey seal between the UK and Dutch sites (see ***Appendix 11.2***).

156. 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. 2018).

157. Tags deployed on grey seals at Donna Nook and Blakeney Point in May 2015, indicated the tagged seal travelled along the coast between haul-out sites on 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 (see ***Appendix 11.2***; Russell 2016).

158. 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).

11.5.2.2 Haul-Out Sites

159. 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 2018).

160. In eastern England, pupping occurs mainly between early November and mid-December (SCOS 2018). 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 2018).

161. The East Anglia ONE North windfarm site is located approximately 36km offshore (at the closest point) which is Southwold. Principal grey seal haul-out sites (and approximate distance to the East Anglia ONE North windfarm site) are Scroby Sands (40km), Horsey Corner (52km), Blakeney Point National Nature Reserve (NNR) (111km), The Wash (157km) and at Donna Nook (184km) (***Figure 11.1***). There are smaller grey seal haul-out sites present along the Essex and Kent coastlines, the closest of which are the Gunfleet Sands and Sunk Sands sites, approximately 88km and 91km respectively from the East Anglia ONE North windfarm site.

162. The landfall for the proposed East Anglia ONE North project will be to the north of Thorpeness, approximately 60km from the Horsey Corner and 120km from the Blakeney Point haul-out sites to the north (***Figure 11.1***).

11.5.2.3 Diet and Foraging

163. Grey seals are generalist feeders, feeding on a wide variety of prey species (SCOS 2018; Hammond and Grellier 2006). Diet varies seasonally and from region to region (SCOS 2018).

164. Grey seals have wide-ranging foraging zones and are capable of travelling large distances between haul-out areas. Grey seals will typically forage within 100km from their haul-out sites (Thompson et al. 1996), although are known to make much longer foraging trips of up to 1,000km (McConnell et al. 1992).

165. Grey seals typically forage in the open sea and return regularly to haul out on land where they rest, moult and breed. Foraging trips can last anywhere between one and 30 days (SCOS 2018).

166. 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 2018). 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 (Matthiopoulos et al. 2004; Russell et al. 2017).

11.5.2.4 Abundance and Density Estimates

167. 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 2018). The pup production estimates are converted to estimates of total population size (1+ aged population) using a mathematical model and projected forward (SCOS 2018).

168. The most recent surveys of the principal grey seal breeding sites Scotland, Wales, Northern Ireland and south-west England, resulted in an estimate of 65,000 pups (95% CI = 57,800-71,800; SCOS 2018). When the pup production estimates are converted to estimates of total population size, there was an estimated 150,000 grey seals in 2017 (approximate 95% CI = 131,000-171,600; SCOS 2018).

169. The estimated adult UK grey seal population size in regularly monitored colonies in 2017 was 137,700 (95% CI = 118,500-155,200), based on pup production and projecting the model forward. This is an increase of approximately 1.8% per year between 2012 and 2017 (SCOS 2018).

170. In the southern North Sea, the rates of increase in pup production from 2010 to 2014 (by an average 22% per year) suggests that there must be some immigration from colonies further north (SCOS 2016). The colonies in the southern North Sea are still increasing in population size, but the rate has been much lower in the last three years, giving an early indication that they may be reaching carrying capacity (SCOS 2018).

171. The most recent counts of grey seal in the August surveys 2008-2017, estimated that the minimum count of grey seals in the UK was 45,119 (SCOS 2018).

11.5.2.4.1 Management Units

172. The most recent August counts (2018) of grey seal at haul-out sites in the south-east England MU provides an estimated abundance of 8,716 grey seal (SCOS 2018). This includes 6,526 grey seals at Donna Nook, 688 at The Wash, 502 at

Blakeney Point, 425 at Scroby Sands and 481 along the Essex and Kent coast (SCOS 2018).

173. For the north-east MU, there is an estimated 7,004 grey seals, based on the most recent counts in 2017 (SCOS 2018). This includes 6,767 grey seals in Northumberland and 27 at The Tees (SCOS 2018).

174. It should be noted that grey seal summer counts are known to be more variable than harbour seal summer counts. Therefore, SCOS (2018) suggests that caution is advised when interpreting these numbers.

175. 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 the Wadden Sea area has been steadily increasing, with a 10% increase from 2016 to 2017 (total of 5,445 in 2017), and again by 13% to 2018, with a total recorded number of 6,144, (TSEG 2016a, 2017a; Brasseur et al. 2018).

11.5.2.4.2 Seal Density Maps

176. 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 11.2***).

177. ***Table 11.14*** shows the grey seal density estimates for the East Anglia ONE North offshore cable corridor, windfarm site and offshore development area which have been calculated from the 5km x 5km cells (Russell et al. 2017) based on the area of overlap with the East Anglia ONE North offshore development area (***Figure 11.2***). The upper at-sea density estimates for these areas have been used in the assessment (***Table 11.14***).

Table 11.14 Grey Seal Density Estimates for the East Anglia ONE North Offshore Development Area (based on Russell et al. 2017)

Density Estimate	Offshore Cable Corridor (individual/km^2)	East Anglia ONE North windfarm site (individual/km^2)	Total for the offshore development area (individual/km^2)
Lower at-sea estimate	0.00009	0.0002	0.0002
Mean at-sea estimate	0.04	0.0006	0.02
Upper at-sea estimate	0.09	0.001	0.03

11.5.2.4.3 East Anglia ONE North Site Specific Surveys

178. A total of 27 individual seals were recorded during the aerial surveys for the proposed East Anglia ONE North project, from September 2016 to August 2018 (24 months), these were not identified to species level (see ***Appendix 11.2***).

179. Relatively low numbers (total of 18 individual seals) were also recorded during the aerial surveys for the proposed East Anglia TWO project, from November 2015 to April 2016, from September 2016 to October 2017, and from May 2018 to August 2018 (24 months), one of these was identified to be a grey seal (SPR 2019).

180. As the number of sightings were too low from the East Anglia ONE North site specific survey within the marine mammal survey area to determine a robust site-specific density estimate for grey seal, the SMRU seals at-sea density data (***Table 11.14***; Russell et al. 2017) has been used in the assessment, as agreed with the marine mammal ETG (meeting 6th March 2018).

11.5.2.5 Reference Population for Assessment

181. The reference population extent for grey seal incorporates the south-east England and north-east England (IAMMWG 2013; SCOS 2018) and the Wadden Sea region (Brasseur et al. 2018).

182. The telemetry studies outlined in ***Appendix 11.2*** justify the inclusion of UK south-east England MU, north east England MU and the Wadden Sea region in the reference population for this assessment. The area is also appropriate for assessing the potential impact of the proposed East Anglia ONE North project alone and in-combination with other projects and plans.

183. It is acknowledged that the UK grey seal counts are based on surveys conducted in August and the Wadden Sea region is based on counts in winter / spring (and is not a population estimate). As outlined in ***section 11.5.2.4***, when the pup

production estimates from autumn counts are converted to estimates of total population size, there was an estimated 150,000 grey seals in 2017 (approximate 95% CI = 131,000-171,600; SCOS 2018). The most recent counts of grey seal in the August surveys 2008-2017, estimated that the minimum count of grey seals in the UK was 45,119 (SCOS 2018). 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.

184. It is also acknowledged that the counts for the Wadden Sea region are not corrected for seals in the water and are therefore an indication of the minimum estimates of the number of seals in the area and not actual population counts.

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

- South-east England MU = 8,716 grey seal (SCOS 2018);
- North-east England MU = 7,004 grey seal (SCOS 2018); and
- The Wadden Sea region = 6,144 grey seal (Brasseur et al. 2018).

186. The total reference population for the assessment is therefore 21,864 grey seal. In addition, the assessment of the potential impacts will also be assessed on the south-east England MU of 8,716 grey seal (***Table 11.16***).

11.5.3 Harbour Seal

187. The information relevant to the assessment for harbour seal has been included in this section, with further information provided in ***Appendix 11.2***.

11.5.3.1 Distribution

188. 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 the East Anglia ONE North offshore development area, with tracks moving along the coast between The Wash and the Thames estuaries (see ***Appendix 11.2***). This is reflected in the harbour seal density estimates for the East Anglia ONE North windfarm site compared to the offshore cable corridor (***Table 11.15***), although harbour seal numbers in the East Anglia ONE North windfarm site and the offshore cable corridor are very low.

189. Aerial surveys conducted for the former East Anglia Zone and East Anglia ONE site, did not record any seals (EAOW 2012, a, b) while boat based surveys at the East Anglia ONE site, recorded three harbour seal (EAOW 2012). Only two unidentified seals were recorded during East Anglia THREE surveys (EATL 2015). The results of the surveys support the tagging data and suggest that there is low usage of the former East Anglia Zone.

190. For the East Anglia THREE EIA (EATL 2015), EATL commissioned SMRU Marine Ltd and IMARES to investigate the connectivity between tagged harbour seal and the East Anglia THREE site plus a 20km buffer area (EATL 2015). The SMRU 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 IMARES telemetry studies indicated the long ranging movements of harbour seal connectivity between Dutch haul out sites and those on the east coast of England (see ***Appendix 11.2***).

191. The total number of seal species recorded during the aerial surveys for the East Anglia TWO windfarm site, from November 2015 to April 2016, from September 2016 to October 2017, and May 2018 to August 2018 (24 months) was 18 seals, one of these was identified to be a grey seal (SPR 2019). See ***section 11.5.3.4.3*** for the results of the East Anglia ONE North site specific survey.

192. 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 East Anglia ONE North offshore development area, and is higher along the coast and cable corridor (***Figure 11.3***; Russell et al. 2017).

11.5.3.2 Haul-Out Sites

193. 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 2018). Harbour seal give birth to their pups in June and July and pups can swim almost immediately after birth (SCOS 2018). Harbour seals moult in August and spend a higher proportion of their time on land during the moult than at other times (SCOS 2018).

194. The principal harbour seal haul-out sites (with approximate distances to the East Anglia ONE North windfarm site) are at Scroby Sands (40km), Blakeney Point (111km) and The Wash (157km) (***Figure 11.1***). Smaller harbour seal haul-out sites along the Essex coastline (with approximate distances to the East Anglia ONE North windfarm site) are at Hamford Water (90km), Buxey Sand (109km) and Margate (117km) (SCOS 2018).

195. The landfall location is approximately 60km from the Horsey Corner and 120km from the Blakeney Point haul-out sites. The Essex coast haul-out sites to the south (with approximate distances to the East Anglia ONE North landfall location) are at Hamford Water (43km) Buxey Sand (65km) site and Margate (84km). The closest point of the Wash and North Norfolk SAC boundary (in which The Wash haul-out sites are located) is 108km from the landfall site (***Figure 11.1***).

11.5.3.3 Diet and Foraging

196. 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 2018).

197. Harbour seal normally forage within 40-50 km around their haul out sites. Although, 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 location and the surrounding marine habitat (see ***Appendix 11.2***).

11.5.3.4 Abundance and Density Estimates

198. Harbour seal are counted while they are on land during their August moult, giving a minimum estimate of population size (SCOS 2018). Combining the most recent counts (2008-2017) gives a total of 32,600 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 2016 of 45,100 harbour seal (approximate 95% CI = 37,000-60,400; SCOS 2018).

11.5.3.4.1 Management Units

199. The most recent August counts (2018) of harbour seal at haul-out sites in the south-east England MU provides an estimated abundance of 4,965 harbour seal (SCOS 2018). This includes 290 harbour seals at Donna Nook, 3,210 at The Wash, 399 at Blakeney Point, 271 at Scroby Sands and 694 along the Essex and Kent coast (SCOS 2018).

200. 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 2018 was estimated to be 40,000, an increase from the 38,100 recorded harbour seals in the 2017 surveys (Galatius et al. 2018).

11.5.3.4.2 Seal Density Maps

201. ***Table 11.15*** shows the harbour seal density estimates for the East Anglia ONE North offshore cable corridor and windfarm site (and total for both areas for the offshore development area), 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 the East Anglia ONE North offshore development area (***Figure 11.3***). The upper at-sea density estimate for these areas have been used in the assessment.

Table 11.15 Harbour Seal Density Estimates (Based on Russell et al. 2017)

Density Estimate	Offshore Cable Corridor (individuals/km^2)	East Anglia ONE North windfarm site (individuals/km^2)	Total for the East Anglia ONE North offshore development area (individuals/km^2)
Lower at-sea estimate	0.003	0.0001	0.001
Mean at-sea estimate	0.01	0.0003	0.004
Upper at-sea estimate	0.02	0.0005	0.008

11.5.3.4.3 East Anglia ONE North Site Specific Surveys

202. A total of 27 individual seals were recorded during the aerial surveys for the proposed East Anglia ONE North project, from September 2016 to August 2018 (24 months); these were not identified to species level (see ***Appendix 11.2***).

203. As outlined above, relatively low numbers (total of 18 individual seals) were also recorded during the aerial surveys for the proposed East Anglia TWO project, from November 2015 to April 2016, from September 2016 to October 2017, and from May to August 2018 (24 months), one of which was identified to be a grey seal (SPR 2019).

204. As the sightings data was too low within the East Anglia ONE North site specific survey area to determine a robust site-specific density estimate for harbour seal, the SMRU seals at-sea density data (***Table 11.15***; Russell et al. 2017) has been used in the assessment, as agreed with the marine mammal ETG (meeting 6th March 2018).

11.5.3.5 Reference Population for Assessment

205. The reference population for harbour seal will incorporate the south-east England MU and the Wadden Sea region. The telemetry studies outlined in ***Appendix 11.2***, justifies the inclusion of UK south-east England MU and the Wadden Sea

region in the reference population for this assessment. The area is also appropriate for assessing the potential impact of the proposed East Anglia ONE North project alone and in-combination with other projects and plans.

206. The UK harbour seal counts are based on surveys conducted in August during the moult period and the Wadden Sea count is based on harbour seal in June during the pupping season (Galatius et al. 2018). Given that harbour seal in the UK also give birth to their pups in June and July (SCOS 2018), there is unlikely to be double counting of seals during these surveys.

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

- South-east England MU = 4,965 harbour seal (SCOS 2018); and
- The Wadden Sea region = 40,000 harbour seal (Galatius et al. 2018).

208. The total harbour seal reference population for the assessment is therefore 44,965. In addition, consideration is also given to the potential impacts on the south-east England MU of 4,965 harbour seal (***Table 11.16***).

11.5.4 Designated Sites and Protected Species

11.5.4.1 Designated Sites for Harbour Porpoise

209. For harbour porpoise, connectivity was considered potentially possible between the proposed East Anglia ONE North project and any designated site within the North Sea MU (IAMMWG 2015).

210. The HRA screening considered any designated 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 designated sites outwith the harbour porpoise North Sea MU area were screened out from further consideration.

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

212. 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).

213. In total, 31 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.

214. The East Anglia ONE North offshore development area is located wholly within the SNS SAC area (***Figure 11.4***). Therefore, any harbour porpoise affected by the proposed East Anglia ONE North project would be within or in close proximity to the SNS SAC.

215. As harbour porpoise are wide-ranging within the North Sea MU, no discrete population can be assigned to an individual designated site. It is, therefore, assumed that at any one time, harbour porpoise within or in the vicinity of the offshore development area are associated with the SNS SAC (as they cannot simultaneously be part of the population of multiple designated sites, although all are part of the larger North Sea MU population).

11.5.4.2 Designated Sites for Grey Seal

216. The HRA screening initially considered a total of 51 European designated sites where grey seal is a qualifying feature and which could have theoretical connectivity with the East Anglia ONE North offshore development area. This list was refined based upon field data to a list of 27 sites with potential connectivity, which were then assessed in terms of the potential for Likely Significant Effect (LSE) of the project.

217. Based upon this process, all sites for grey seal, with the exception of the Humber Estuary SAC, which is 174km at its closest point to the cable corridor route, were screened out from further assessment in the HRA for grey seal.

11.5.4.3 Designated Sites for Harbour Seal

218. The HRA screening initially considered a total of 74 European designated sites where harbour seal is a qualifying feature and which could have theoretical connectivity with the proposed East Anglia ONE North project. This list was refined based upon field data to a list of 20 sites with potential connectivity which was then assessed in terms of the potential for LSE of the project.

219. Based upon this process, all sites for harbour seal, with the exception of the Wash and North Norfolk Coast SAC (100km at its closest point to the offshore cable corridor), were screened out from further assessment in the Information to Support Appropriate Assessment for harbour seal.

11.5.5 Anticipated Trends in Baseline Conditions

220. The existing baseline conditions for marine mammals within the study area (described in ***section 11.5*** and ***Appendix 11.2***) 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 windfarms 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.

221. 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).

222. 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 2018). Pup production at colonies in the North Sea increased rapidly up to 2016, with an annual increase of 8% per year from 2014 to 2016, slightly lower than the 10.8% growth between 2012 and 2014 and the 12% increase between 2010 and 2012 (SCOS 2018). The majority of the increase up to 2016 was due to the continued rapid expansion of newer colonies on the mainland coasts in Berwickshire, Lincolnshire, Norfolk and Suffolk (SCOS 2018).

223. The 2015 and 2016 grey seal 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 in population growth rates after 12 years of extremely rapid increase (of more than 30% per year) (SCOS 2018). The same slow down in the rate of population growth can be seen at both Donna Nook and Horsey (SCOS 2018). 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). The rate of increase

in the southern North Sea has been lower in recent years, giving an early indication that this population may be reaching carrying capacity (SCOS 2018).

224. Overall, the UK population of harbour seal has increased since the late 2000s and is close to the 1990s level (SCOS 2018). However, there are significant differences in the population dynamics between regions, for example there have been general declines in the counts of harbour seals in several regions around Scotland but the declines are not universal, with some populations either stable or increasing (SCOS 2018). Counts for the East coast of England appear stable, although the 2017 count was 3.9% lower than in 2016, and similar to the counts in of 2014 and 2015; this may be an early indication that the population is nearing carrying capacity (SCOS 2018).

225. 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 2018). 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 2018). The decline in the rate of increase in the Wadden Sea could be related to the population reaching carrying capacity (SCOS 2018).

11.5.6 Summary of Marine Mammal Receptors and Reference Populations

226. ***Table 11.16*** and ***Table 11.17*** provide a summary of the reference populations and the density estimates for the marine mammal species being taken forward for the impact assessment.

227. During the impact assessment, the magnitude of impacts will be put in context against these reference populations (see ***Table 11.10*** for definitions of magnitude).

Table 11.16 Summary of Marine Mammal Reference Populations Used in the Impact Assessment

Species	Reference Population Extent	Year of Estimate	Size	Data Source
Harbour porpoise	North Sea MU	2016	345,373 (CV = 0.18; 95% CI = 246,526-495,752)	SCANS-III (Hammond et al. 2017)
Grey seal	South-east England MU; North-east England MU; Wadden Sea population	2016; 2016; 2017	8,716 + 7,004 + 6,144 = 21,864	SCOS 2018 Brauseur et al. 2018
	South-east England MU	2016	8,716	SCOS 2017
Harbour seal	South-east England MU; Wadden Sea population	2016; 2017	4,965 + 40,000 = 44,965	SCOS 2018 Galatius et al. 2018
	South-east England MU	2016	4,965	SCOS 2018

Table 11.17 Summary of Marine Mammal Density Estimates Used in the Impact Assessment

Species	Density Estimate (number of individuals per km^2)	Data Source
Harbour porpoise	0.58/km^2 for the East Anglia ONE North windfarm site*	Site specific surveys (***Appendix 11.2***)
	0.607/km^2	SCANS-III survey block L (Hammond et al. 2017)
Grey seal	0.001/km^2 for the East Anglia ONE North windfarm site 0.09/km^2 for the East Anglia ONE North export cable corridor 0.03/km^2 for the East Anglia ONE North offshore development area	Russell et al. 2017**
Harbour seal	0.0005/km^2 for the East Anglia ONE North windfarm site 0.02km^2 for the East Anglia ONE North export cable corridor 0.008/km^2 for the East Anglia ONE North offshore development area	Russell et al. 2017**

** based on the mean annual density estimate of highest monthly counts and seasonal CFs of harbour porpoise counts combined with unidentified dolphin/porpoise counts*
*** based on the upper at-sea counts from Russell et al. (2017) within the actual project areas only*

11.6 Potential Impacts

228. Potential impacts and methodologies for assessment considered within the EIA were agreed with the ETG through the Marine Mammal Method Statement (SPR 2017a) discussed 30th of May 2017 (see ***Appendix 11.1***).

229. Prior to construction, MMMPs designed to reduce the potential risk of physical and auditory injury from piling and UXO clearance will be prepared in consultation with the MMO and relevant SNCBs and will be based on the latest guidance and mitigation techniques (see ***section 11.3.3***). A combined draft MMMP has been submitted with the DCO application (document reference 8.14) for both UXO clearance and piling, however, two separate MMMPs, one for piling and one for UXO clearance will be prepared in consultation with the MMO and relevant SNCBs during the pre-construction period.

11.6.1 Potential Impacts During Construction

230. Potential impacts during construction may arise through disturbance from activities during the installation of offshore infrastructure. Underwater noise during piling, as well as disturbance associated with underwater noise from other construction activities and the presence of vessels offshore, are considered. Potential displacement from important habitat areas and indirect impacts on prey species is also considered.

231. The potential impacts during construction assessed for marine mammals are:

- Physical and auditory injury resulting from the underwater noise associated with clearance of UXO;
- Behavioural impacts resulting from the underwater noise associated with clearance of 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;
- Underwater noise and disturbance from construction vessels;
- Barrier effects as a result of underwater noise;
- Vessel interaction (collision risk); and
- Changes to prey resource.

232. The realistic worst-case scenario on which the assessment is based for marine mammal receptors is outlined in ***Table 11.2***.

11.6.1.1 Impact 1: Physical and Auditory Injury Resulting from the Underwater Noise Associated with Clearance of Unexploded Ordnance (UXO)

233. There is the likely requirement for UXO clearance prior to construction. Whilst any underwater UXO that are identified would preferentially be avoided, it is necessary to consider the potential for underwater UXO detonation where retrieval is deemed to be unsafe and avoidance is not possible.

234. A detailed UXO survey would be completed prior to construction. The exact number of possible detonations and duration of UXO clearance operations is therefore not known at this stage. It has been estimated, based on the UXO survey for the currently under-construction East Anglia ONE project (East Anglia ONE Limited 2018), that there could be up to 80 UXO within the East Anglia ONE North offshore development area. As a worst-case scenario, it has been assumed that the maximum duration of UXO clearance would be 80 days, based on one UXO detonation per 24 hour period.

235. It is not currently known the size or type of the UXO that could be present, therefore a range of charge sizes, based on the UXO survey for East Anglia ONE (East Anglia ONE Limited 2018), has been assessed, with the maximum charge weight of up to 700kg. This is also consistent with other projects, such as Norfolk Vanguard (Norfolk Vanguard Limited 2018).

236. 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 beyond 10m from source.

237. 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:

- 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;
- 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

- Behavioural change, such as disturbance to feeding, mating, breeding, and resting.

238. Studies of blast effects on cetaceans indicate that smaller species are typically at greatest risk for shock wave or blast injuries (Ketten 2004; von Benda-Beckmann et al. 2015).

239. The severity of the consequences of UXO detonation will depend on many variables, but principally, on the charge weight and its proximity to the receptor. 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.

240. 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).

241. 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^2s, which exceeded by 1 dB the SEL-based risk threshold above which PTS was considered very likely in harbour porpoise (190dB re 1 μPa^2s), and exceeded by 12dB, the lower limit of PTS onset in harbour porpoise (179dB re 1 μPa^2s). 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 metres and 15km for the charge masses ranging from 10 to 1,000kg (von Benda-Beckmann et al. 2015).

11.6.1.1.1 Sensitivity

242. 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 11.8***).

243. The sensitivity of marine mammals to TTS onset and flee response / likely disturbance as a result of underwater UXO detonations is considered to be medium in this assessment as a precautionary approach. This is for animals within the potential TTS onset and flee response / likely disturbance range, but beyond the potential impact range for auditory injury. Marine mammals within the potential impact area are considered to have limited capacity to avoid such effects (***Table 11.8***), although any impacts on marine mammals would be temporary and they would be expected to return to the area once the activity had ceased.

11.6.1.1.2 Underwater Noise Modelling

244. As outlined above, a number of UXOs with a range of charge weights could be located within the East Anglia ONE North offshore development area. There is expected to 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 been submitted to different environmental factors.

245. 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 survey for East Anglia ONE (East Anglia ONE Limited 2018) and assessment for Norfolk Vanguard (Norfolk Vanguard Limited 2018). 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.

246. The noise produced by the detonation of explosives is affected by a number of different elements (e.g. its design, composition, age, position, orientation, whether it is covered by sediment) which 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. 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.

247. The assessment 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. 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.

248. The impact criteria use thresholds and weightings based on the NOAA (NMFS 2018) criteria (***Table 11.18***). Note that the Southall et al. (2019) Marine Mammal Noise Exposure Criteria are the same as for the NMFS (2018) criteria for which the following assessments are based. The thresholds indicate the onset of PTS, the point at which there is an increase in risk of permanent hearing damage in an underwater receptor (although not all individuals within the maximum PTS range will have permanent hearing damage, this is assumed as a worst-case scenario). These indicators 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.

249. Peak noise levels are difficult to predict accurately in a shallow water environment (von Benda Beckmann et al. 2015) and would tend to be significantly over-estimated by the modelling over increased distances from the source. With increased distance from the source, impulsive noise, such as UXO detonation, noise becomes more of a non-impulsive noise, unfortunately it is currently difficult to determine the distance at which an impulsive noise becomes more like a non-impulsive noise. Therefore, modelling was conducted using both the impulsive and non-impulsive criteria for PTS weighted Sound Exposure Levels (SEL) to give an indication of the difference between maximum potential impact ranges.

250. Impulsive noise sources are described as having a rapid rise time, short duration and high peak pressure. A study into the distance at which underwater noise sources (from offshore windfarm piling and seismic surveys) ‘transformed’ from an impulsive to a non-impulsive noise revealed that, at a distance of between 2 and 3km, the noise sources no longer contained the characteristics (in particular a high enough peak pressure) to be classed as an impulsive noise (Hastie et al. 2019). However, this study was completed in a shallow water environment, with a relatively flat seabed, and the actual range at which a sound source transforms into a non-impulsive noise is likely to be dependent on a number of environmental variables and other sound source characteristics (Hastie et al. 2019).

251. As outlined in ***Appendix 11.4***, it is suggested that, for any injury ranges calculated using the impulsive criteria in excess of 5km, the non-pulse criteria should be considered more appropriate.

252. The use of NOAA (NMFS 2018) weighted SEL is considered more suitable, especially over long ranges, as it takes into account the hearing sensitivity of the species. However, as a precautionary approach, the assessment has been based on the worst-case scenarios for the unweighted peak Sound Pressure Levels (SPL_{peak}).

11.6.1.1.3 Permanent Auditory Injury (PTS)

253. The number of harbour porpoise, grey seal and harbour seal that could potentially be impacted was estimated for the offshore development area, based on the maximum potential PTS impact ranges per UXO detonation (***Table 11.18***). The resulting magnitude is assessed to be medium for harbour porpoise, low for grey seal and negligible for harbour seal, without mitigation.

Table 11.18 Potential Maximum Impact of Permanent Auditory Injury (PTS) on Marine Mammals During UXO Clearance Without Mitigation

Species	PTS Criteria Threshold	Possible maximum charge weight				Magnitude
		200kg	300kg	500kg	700kg	
		Maximum predicted impact range (km) and area* (km2)				
Harbour porpoise (high-frequency cetacean)	PTS SPL_{peak} 202 dB re 1 µPa Unweighted (NMFS 2018) Impulsive criteria	7.8km ($191km^2$)	8.8km ($243km^2$)	10.2km ($327km^2$)	11.1km ($387km^2$)	
	PTS SEL 155 dB re 1 $µPa^2s$ Weighted (NMFS 2018) Impulsive criteria	2.1km ($14km^2$)	2.5km ($20km^2$)	3.1km ($30km^2$)	3.6km ($41km^2$)	
	PTS SEL 173 dB re 1 $µPa^2s$ Weighted (NMFS 2018) Non-impulsive criteria	0.093km ($0.03km^2$)	0.11km ($0.04km^2$)	0.14km ($0.06km^2$)	0.17km ($0.09km^2$)	
	Maximum number of harbour porpoise and % of reference population based on maximum potential	235 harbour porpoise (0.07% of NS MU) based on SCANS-III survey density ($0.607/km^2$). 224 harbour porpoise (0.06% of NS MU) based on site specific survey density ($0.58/km^2$) at EA1N.				Permanent effect with medium magnitude (i.e. between 0.01% and 1% of the reference population

Species	PTS Criteria Threshold	Possible maximum charge weight 200kg Maximum predicted impact range (km) and area* (km2)	300kg	500kg	700kg	Magnitude
	impact area* (387km²) for PTS unweighted SPL_{peak}					anticipated to be exposed to effect).
	Number of harbour porpoise and % of reference population based on maximum impact area* (0.09-41km²) for PTS weighted SEL impulsive and non-impulsive criteria	0.06-25 harbour porpoise (0.00002-0.007% of NS MU) based on SCANS-III survey density (0.607/km²). 0.05-23.7 harbour porpoise (0.00001-0.007% of NS MU) based on site specific survey density (0.58/km²) at EA1N.				Permanent effect with low magnitude (i.e. between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).
Grey seal and harbour seal (pinnipeds in water)	PTS SPL_{peak} 218 dB re 1 µPa Unweighted (NMFS, 2018) Impulsive criteria	1.7km (9.08km²)	1.9km (11.34km²)	2.3km (16.62km²)	2.6km (21.24km²)	
	PTS SEL 185 dB re 1 µPa²s	1.0km (3.14km²)	1.2km (4.52km²)	1.5km (7.07km²)	1.8km (10.18km²)	

Species	PTS Criteria Threshold	Possible maximum charge weight				Magnitude
		200kg	300kg	500kg	700kg	
		Maximum predicted impact range (km) and area* (km2)				
	Weighted (NMFS, 2018) Impulsive criteria					
	PTS SEL 201 dB re 1 µPa²s Weighted (NMFS, 2018) Non-impulsive criteria	0.06km (0.01km²)	0.08km (0.02km²)	0.1km (0.03km²)	0.11km (0.04km²)	
Grey Seal	Maximum number of grey seal and % of reference population based on maximum potential impact area* (21.24km²) for PTS unweighted SPL_{peak}	0.6 grey seal (0.003% ref pop; 0.007% SE England MU) based on the offshore development area density (0.03/km²).				Permanent effect with low magnitude (i.e. between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).
	Number of grey seal and % of reference population based on maximum impact area* (0.04-10.18km²) for PTS weighted SEL	0.001-0.3 grey seal (0.000005-0.001% ref pop; 0.00001-0.004% SE England MU) based on the offshore development area density (0.03/km²).				Permanent effect with low magnitude (i.e. between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).

Species	PTS Criteria Threshold	Possible maximum charge weight 200kg / 300kg / 500kg / 700kg Maximum predicted impact range (km) and area* (km2)	Magnitude
	impulsive and non-impulsive criteria		
Harbour seal	Maximum number of harbour seal and % of reference population based on maximum potential impact area* (21.24km^2) for PTS unweighted SPL_{peak}	0.2 harbour seal (0.0004% ref pop; 0.003% SE England MU) based on the offshore development area density (0.008/km^2).	Permanent effect with negligible magnitude (i.e. less than 0.001% of the reference population anticipated to be exposed to effect).
	Number of harbour seal and % of reference population based on maximum impact area* (0.04-10.18km^2) for PTS weighted SEL impulsive and non-impulsive criteria	0.0003-0.08 harbour seal (0.000001-0.0002% ref pop; 0.000006-0.002% SE England MU) based on the offshore development area density (0.008/km^2).	Permanent effect with negligible magnitude (i.e. less than 0.001% of the reference population anticipated to be exposed to effect).

**Maximum area based on area of circle with maximum impact range for radius as worst-case scenario.*

Table 11.19 Potential Maximum Impact of Temporary Auditory Injury (TTS) and Fleeing Response on Marine Mammals During UXO Clearance

Species	TTS Criteria Threshold	Possible maximum charge weight				Magnitude
		200kg	300kg	500kg	7000kg	
		Maximum predicted impact range (km) and area* (km2)				
Harbour porpoise (high-frequency cetacean)	TTS SPL_{peak} 196 dB re 1 µPa Unweighted (NMFS 2018) Impulsive criteria	13km ($531km^2$)	15km ($707km^2$)	17km ($908km^2$)	18km ($1,018km^2$)	
	TTS SEL 140 dB re 1 μPa^2s Weighted (NMFS 2018) Impulsive criteria	17km ($908km^2$)	20km ($1,257km^2$)	23km ($1,662km^2$)	25km ($1,964km^2$)	
	TTS SEL 153 dB re 1 μPa^2s Weighted (NMFS 2018) Non-impulsive criteria	2.9km ($26km^2$)	3.4km ($36km^2$)	4.3km ($58km^2$)	5.0km ($78km^2$)	
	Maximum number of harbour porpoise and % of reference population based on maximum potential	1,192 harbour porpoise (0.35% of NS MU) based on SCANS-III survey density ($0.607/km^2$). 1,139 harbour porpoise (0.33% of NS MU) based on site specific survey density ($0.58/km^2$) at EA1N.				Temporary effect with negligible magnitude (i.e. less than 1% of the reference population

Species	TTS Criteria Threshold	Possible maximum charge weight 200kg	300kg	500kg	7000kg	Magnitude
		Maximum predicted impact range (km) and area* (km2)				
	impact area* (1,964km^2) for TTS					anticipated to be exposed to effect).
Grey seal and harbour seal (pinnipeds in water)	TTS SPL_{peak} 212 dB re 1 µPa Unweighted (NMFS, 2018) Impulsive criteria	3.1km (30km^2)	3.5km (38km^2)	4.1km (53km^2)	4.6km (66km^2)	
	TTS SEL 170 dB re 1 µPa^{2}s Weighted (NMFS, 2018) Impulsive criteria	11km (380km^2)	12km (452km^2)	14km (616km^2)	16km (804km^2)	
	PTS SEL 201 dB re 1 µPa^{2}s Weighted (NMFS, 2018) Non-impulsive criteria	2.0km (13km^2)	2.4km (18km^2)	3.0km (28km^2)	3.5km (38km^2)	

Species	TTS Criteria Threshold	Possible maximum charge weight 200kg 300kg 500kg 7000kg Maximum predicted impact range (km) and area* (km2)	Magnitude
Grey Seal	Maximum number of grey seal and % of reference population based on maximum potential impact area* (804km^2) for TTS	24 grey seal (0.1% ref pop; 0.3% SE England MU) based on the offshore development area density (0.03/km^2).	Temporary effect with negligible magnitude (i.e. less than 1% of the reference population anticipated to be exposed to effect).
Harbour seal	Maximum number of harbour seal and % of reference population based on maximum potential impact area* (804km^2) for TTS	6 harbour seal (0.01% ref pop; 0.1% SE England MU) based on the offshore development area density (0.008/km^2).	Temporary effect with negligible magnitude (i.e. less than 1% of the reference population anticipated to be exposed to effect).

**Maximum area based on area of circle with maximum impact range for radius as worst-case scenario.*

11.6.1.1.4 Temporary Auditory Injury and Fleeing Response

254. TTS ranges have been modelled and are presented for information. However, it should be noted that the assessment of magnitude of effect or overall effect significance is likely to overestimate the potential for any significant effect. The TTS onset thresholds used in the NOAA (NMFS 2018) criteria, are determined as a basis to predict when PTS might occur (rather than conducting experiments to induce permanent auditory injury (PTS) in marine mammals).

255. The number of harbour porpoise, grey seal and harbour seal that could potentially by impacted is estimated based on the maximum potential TTS impact ranges for UXO clearance (***Table 11.19***). The resulting effect is shown to be of negligible magnitude for harbour porpoise, grey seal and harbour seal, without mitigation.

256. 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.

11.6.1.1.5 Impact Significance

257. The impact significance for any physical injury or permanent auditory injury (PTS) without mitigation has been assessed as **major to moderate adverse** for harbour porpoise, **moderate adverse** for grey seal and **minor adverse** for harbour seal (***Table 11.20***).

258. It should be noted that the conclusion of major and moderate adverse without mitigation for PTS in harbour porpoise and grey seal respectively 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 East Anglia ONE North offshore development area.

259. The risk of TTS in harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** for UXO clearance, with no mitigation (***Table 11.20***).

11.6.1.1.5.1 Mitigation

260. As outlined in ***section 11.3.3.3.2***, 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 East Anglia ONE North offshore development area and detailed project design. The draft DCO includes the requirement for a UXO method statement, including information on the identification and investigation of potential UXO targets, clearance of UXO, locations where UXO will be cleared and a

programme of works. 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.

261. A combined draft MMMP has been submitted with the DCO Application (document reference 8.14) for both UXO clearance and piling, however, separate MMMPs for piling and UXO clearance will be prepared in-consultation with the relevant SNCBs during the pre-construction period prior to any UXO clearance activities.

262. An EPS licence application, if required, will be submitted post-consent. At this time, pre-construction UXO surveys will have been conducted and full consideration will have been given to any necessary mitigation measures that may be required following the development of the MMMP for UXO clearance.

11.6.1.1.5.2 Residual Impact

263. 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 (PTS), is likely to reduce to **minor adverse (not significant)** (***Table 11.20***).

Table 11.20 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 to low	Major to moderate adverse	MMMP for UXO clearance	**Minor adverse**
	Grey seal	High	Low	Moderate adverse		**Minor adverse**
	Harbour seal	High	Negligible	Minor adverse		**Minor adverse**
Temporary auditory injury (TTS) and fleeing response during underwater UXO clearance	Harbour porpoise	Medium	Negligible	Minor adverse	MMMP for UXO clearance	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**

11.6.1.2 Impact 2: Behavioural Impacts Resulting from the Underwater Noise Associated with Clearance of Unexploded Ordnance (UXO)

11.6.1.2.1 Sensitivity

264. 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. This is for animals within the potential disturbance range but beyond the potential impact range for auditory injury (see ***section 11.6.1.1.1***). Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects (***Table 11.8***), although any disturbance to marine mammals would be temporary and they would be expected to return to the area once the disturbance had ceased.

11.6.1.2.2 Disturbance

265. 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.

266. The SNCBs currently recommend that a potential disturbance range of 26km (approximate area of 2,124km^2) around UXO detonations is used to assess harbour porpoise disturbance in the SNS SAC. The East Anglia ONE North offshore development area is located wholly within the SNS SAC winter area and partly within the summer area; therefore, this approach has been used for the EIA (as well as the HRA) and applied to all species.

267. 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 11.21***. The resulting effect is shown to be of negligible magnitude for all species.

268. Disturbance from any UXO detonations would be temporary and for a short-duration (i.e. the detonation). For the estimated worst-case (***Table 11.21***) it is predicted that there could be up to 80 clearance operations in the East Anglia ONE North offshore development area. As a precautionary worst-case scenario, the maximum number of days of UXO clearance could be up to 80 days, based on one detonation per day within the overall UXO clearance operation, which could be conducted over several months.

Table 11.21 Estimated Number of Harbour Porpoise, Grey Seal and Harbour Seal that Could Potentially be Disturbed During UXO Clearance and Magnitude of Effect

Potential Impact	Receptor	Estimated number in impact area	% of reference population	Magnitude
Area of disturbance (2,124km²) during underwater UXO clearance	Harbour porpoise	1,289 harbour porpoise based on SCANS-III survey density (0.607/km²).	0.4% of NS MU based on SCANS-III density.	Temporary effect with negligible magnitude (i.e. less than 1% of the reference population anticipated to be exposed to effect).
		1,232 harbour porpoise based on site specific survey density (0.58/km²).	0.37% of NS MU based on the site specific survey density at EA1N.	
	Grey seal	64 grey seal based on density (0.03/km²) in the offshore development area.	0.3% ref pop (0.7% SE England MU)	Temporary effect with negligible magnitude
	Harbour seal	17 harbour seal based density (0.008/km²) in the offshore development area.	0.04% ref pop (0.3% SE England MU)	Temporary effect with negligible magnitude

11.6.1.2.3 Impact Significance

269. The potential disturbance has been assessed as **minor adverse (not significant)** for harbour porpoise, grey seal and harbour seal during UXO clearance, with no mitigation (***Table 11.22***).

270. Disturbance from any UXO detonations would be temporary and for a short-duration (i.e. the detonation).

271. In addition to the MMMPs for UXO clearance, if required, an East Anglia ONE North SNS SAC SIP will be developed (***section 11.3.3.3.3***). The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SNS SAC, in particular the significant disturbance of harbour porpoise. Any measures put in place to reduce the effects on harbour porpoise would also reduce any impacts on grey and harbour seal.

Table 11.22 Assessment of Impact Significance for Disturbance of Marine Mammals During UXO Clearance

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Disturbance during underwater UXO clearance	Harbour porpoise	Medium	Negligible	Minor adverse	No further mitigation other than SIP for SNS SAC, if required.	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		
	Harbour seal	Medium	Negligible	Minor adverse		

11.6.1.3 Impact 3: Physical and Auditory Injury Resulting from Underwater Noise during Piling

272. A range of foundation options are being considered for the proposed East Anglia ONE North project, including monopile, jacket (pin-piles), jacket (on suction caissons), gravity base and suction caisson. Of these, monopiles and jackets (pin-piles) may require piling. 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). As a worst-case scenario for underwater noise, it has been assumed that all foundations would be hammer piled, using the maximum hammer energy applied and pile diameter for the maximum potential duration to install (***Table 11.2***).

273. 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. High exposure levels from underwater noise sources can cause auditory injury or hearing impairment taking the form of a permanent loss of hearing sensitivity (PTS) 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.

274. 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 (dependent upon species);
- Propagation range, which is dependent upon;
    - Sediment/sea floor composition; and

  - o Water depth;
- Duration of exposure;
- Distance of the animal to the source; and
- Ambient noise levels.

11.6.1.3.1 Underwater Noise Modelling

275. Underwater noise modelling was carried out by Subacoustech to estimate the noise levels likely to arise during piling at the East Anglia ONE North windfarm site and determine the potential impacts on marine mammals using the INSPIRE (impulsive Noise Propagation and Impact Estimator) subsea noise propagation model (***Appendix 11.4***). The INSPIRE model is a semi-empirical noise propagation model based on the use of a combination of numerical modelling and actual measured underwater noise data. It was designed to calculate the propagation of noise in shallow, mixed water, typical of both conditions around the UK and therefore the East Anglia ONE North windfarm site.

276. The modelling considers a wide array of input parameters, including variations in bathymetry 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; and
- Receptor swim speeds.

11.6.1.3.1.1 Piling Locations

277. Modelling was undertaken at two representative locations; one in the deepest point of the East Anglia ONE North windfarm site (typically the worst-case location; i.e. the deepest location where piling can take place, which tends to give the greatest noise propagation) at a water depth of 55m and at an average water depth of the site at a location with a water depth of 47.5m (***Appendix 11.4***).

278. The worst-case scenario was based on the maximum impact range modelled for either location and were used to inform the assessment of the maximum potential impacts on receptor groups, in order to provide a conservative assessment.

11.6.1.3.1.2 Hammer Energy, Soft-start and Ramp-up

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

- Monopile (300m wind turbine) with maximum diameter of 15m, maximum hammer energy to be applied of 4,000kJ and maximum starting energy of 400kJ (secured within the DCO and through the MMMP).
- Pin-pile (300m wind turbine) with minimum diameter of 4.6m, maximum hammer energy to be applied of 2,400kJ and maximum starting hammer energy of 240kJ (secured within the DCO and through the MMMP).

280. To determine the potential for PTS or TTS from cumulative sound exposure level (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 80% of the maximum hammer energy applied, then as a worst-case scenario it is assumed to be 100% maximum hammer energy applied for the remaining duration of the pile installation (maximum hammer energy to be applied is only likely to be required at a few of the piling installation locations and for shorter periods of time). The soft-start, ramp-up and piling duration used to assess SEL_{cum} for monopiles and pin-piles are summarised in ***Table 11.23***.

Table 11.23 Hammer Energy, Ramp-Up and Piling Duration

Parameter	Starting hammer energy (10%)	Ramp-up to 80%	Maximum applied hammer energy (100%)
Monopile			
Hammer energy	400kJ	Gradual increase from 400kJ to 3,200kJ	4,000kJ
Duration	10 minutes	20 minutes	Up to 295 minutes
Strike rate	15 strikes per minute	15 strikes per minute	30 strikes per minute
Number of strikes	150	300	8,850
Pin-pile			
Hammer energy	240kJ	Gradual increase from 240kJ to 1,920kJ	2,400kJ
Duration	10 minutes	20 minutes	Up to 169 minutes for one pin-pile
Strike rate	15 strikes per minute	15 strikes per minute	40 strikes per minute
Number of strikes	150	300	6,760

11.6.1.3.1.3 Environmental Conditions

281. The semi-empirical nature of the INSPIRE model considers the seabed type and speed of sound in water for the mixed conditions around the East Anglia ONE North windfarm site. Mean tidal depth has been used for the bathymetry as the tidal state will fluctuate throughout installation of the foundations (see ***Appendix 11.4***).

11.6.1.3.1.4 Baseline Ambient Noise

282. In principle, when noise is introduced by anthropogenic sources, and propagates far enough from the source, it will reduce to the level of ambient noise levels, at which point it is considered negligible. As the underwater noise thresholds used within the modelling are all considerably above the level of background noise, the noise baseline is not featured in the assessment (***Appendix 11.4***).

11.6.1.3.1.5 Noise Source Levels

283. Underwater noise modelling requires knowledge of the source level, which is the theoretical noise level at 1m from the noise source. The INSPIRE noise propagation model assumes that the noise acts as a single point source, which is adjusted to take into account water depth at the source location to allow for the length of pile in contact with the water, which affects the amount of noise that is transmitted from the pile into surroundings (***Appendix 11.4***).

284. The unweighted SPL_{peak} and SEL_{ss} (see ***section 11.6.1.3.1.6*** for description) source levels estimated for this assessment are provided in ***Table 11.24***.

Table 11.24 Unweighted SPL_{peak} and SEL_{ss} Source Levels Used in Underwater Noise Modelling for Maximum and Starting Hammer Energy of Monopiles and Pin-Piles

Source Level	Maximum monopile source level (4,000kJ)	Maximum pin-pile source level (2,400kJ)	Starting monopile source level (400kJ)	Starting pin-pile source level (240kJ)
SPL_{peak} dB re 1 µPa @ 1 m	239.6	239.2	235.4	233.1
SEL_{ss} dB re 1 µPa²s @ 1 m	223.3	222.9	219.0	216.8

11.6.1.3.1.6 Thresholds and Criteria

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

286. The 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.

287. 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.

288. 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 11.4***).

289. 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 applied.

290. 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 11.23***). 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 1.97m/s (7.1km/h) and during quiet baseline periods the mean swimming speed was 1.2m/s (4.3km/h; Kastelein et al. 2018).

291. 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.

292. The assessment in the ES considers the metrics and criteria from NOAA (NMFS 2018) 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.

293. NOAA (NMFS 2018) 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. The NOAA guidance (NMFS 2018) 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 hearing damage could occur in a species group with reference to the species group's hearing sensitivity.

294. NMFS (2018) presents 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.

295. The NOAA (NMFS 2018) metrics and criteria used in the underwater noise modelling are summarised in ***Table 11.25***. NOAA (NMFS 2018) groups marine mammals into functional hearing groups and applies filters to the unweighted noise to approximate the hearing sensitivity of the receptor.

Table 11.25 NOAA (NMFS 2018) Metrics and Criteria Used in the Underwater Noise Modelling

Species or species group	Impact	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{ss} and SEL_{cum} Weighted (dB re 1 µPa^{2}s)	
			Impulsive	Non-impulsive
Harbour porpoise High Frequency Cetaceans (HF)	Auditory Injury - PTS (Permanent Threshold Shift)	202 (impulsive criteria)	155	173
	TTS and fleeing response (Temporary Threshold Shift)	196 (impulsive criteria)	140	153
Grey seal and harbour seal Pinnipeds in water (PW)	Auditory Injury - PTS (Permanent Threshold Shift)	218 (impulsive criteria)	185	201
	TTS and fleeing response (Temporary Threshold Shift)	212 (impulsive criteria)	170	181

296. 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 11.26***).

Table 11.26 Lucke et al. (2009) Metrics and Criteria Used in the Underwater Noise Modelling

Species	Impact	SEL Unweighted (dB re 1 μPa²s)
Harbour porpoise	Possible Behavioural Response	145

11.6.1.3.1.7 Assumptions and Considerations

297. 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 is not limited to:

- The maximum hammer energy to be applied and maximum piling duration is assumed for all piling locations; however, it is unlikely that maximum hammer energy applied and duration will be required at the majority of piling locations (see ***paragraphs 365*** to ***367***).
- 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 modelled for a single strike are from the piling location and do not take into account (i) the distance marine mammals could move away from the piling location during mitigation measures, such as soft-start and ramp up 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.

298. The assumption that fleeing animals (harbour porpoise, grey seal and harbour seal) are swimming at a constant speed of 1.5m/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.

299. 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.

300. 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.

301. 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).

302. 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. (2013) 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 $\mu Pa^2 s$; the point at which all animals are predicted to have PTS.

11.6.1.3.2 Permanent Auditory Injury (PTS)

303. Permanent auditory injury is often defined as a Permanent Threshold Shift (PTS), in that following exposure to high noise levels there is a threshold shift in the marine mammal's hearing which does not return to normal once sound exposure has ceased, resulting in a permanent auditory injury to the marine mammal.

304. PTS can occur instantaneously from acute exposure to high noise levels, such as single strike (SEL_{ss}) of the maximum hammer energy applied during piling. PTS can also occur as a result of prolonged exposure to increased noise levels, such as during the duration of pile installation (SEL_{cum}).

11.6.1.3.2.1 Sensitivity

305. 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). As such, sensitivity to PTS from pile driving noise is assessed as high for harbour porpoise (***Table 11.27***).

306. 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 sensitive 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 expected to be lower than harbour porpoise, with the individual showing some tolerance to avoid, adapt to or accommodate or recover from the impact (for example, Russell et al. 2016), but as a precautionary approach they are also considered as having high sensitivity in this assessment (***Table 11.27***).

307. The effect would be permanent and marine mammals within the potential impact area are considered to have very limited capacity to avoid such effects, and unable to recover from the effects (***Table 11.8***).

Table 11.27 Summary of Marine Mammal Sensitivity to Noise Impacts from Pile Driving

Species	Auditory Injury (PTS)	TTS / Fleeing Response	Disturbance	Possible Behavioural Response
Harbour porpoise	High	Medium	Medium	Low
Grey and harbour seal	High	Medium	Medium	No criteria currently available

11.6.1.3.2.2 Magnitude

308. 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 11.28***.

Table 11.28 Maximum Predicted Impact Ranges (and Areas) for Permanent Auditory Injury (PTS) from a Single Strike and from Cumulative Exposure Based on NOAA (NMFS 2018) Criteria

Receptor	Potential Impact	Criteria and threshold	Maximum predicted impact range (km) and area (km^2)			
			Monopile		Pin-pile	
			Starting hammer energy (400kJ)	Maximum hammer energy (4,000kJ)	Starting hammer energy (240kJ)	Maximum hammer energy (2,400kJ)
Harbour porpoise	PTS without mitigation – single strike	NMFS (2018) unweighted SPL_{peak} 202 dB re 1 µPa	0.58km (1.04km^2)	1.2km (4.6km^2)	0.38km (0.45km^2)	1.2km (4.1km^2)
		NMFS (2018) SEL_{ss} weighted 155 dB re 1 µPa^{2}s	<0.05km (<0.01km^2)	0.07km (0.02km^2)	0.13km (0.05km^2)	0.4km (0.5km^2)
	PTS from cumulative SEL (including soft-start and ramp-up)	NMFS (2018) SEL_{cum} Weighted 155 dB re 1 µPa^{2}s	N/A	6.6km (92km^2)	N/A	21km* (1,000km^2)
Grey seal and harbour seal	PTS without mitigation – single strike	NMFS (2018) unweighted SPL_{peak} 218 dB re 1 µPa	<0.05km (<0.01km^2)	0.06km (0.01km^2)	<0.05km (<0.01km^2)	0.06km (0.01km^2)
		NMFS (2018) SEL_{ss} Weighted 185 dB re 1 µPa^{2}s	<0.05km (<0.01km^2)	0.05km (0.01km^2)	<0.05km (<0.01km^2)	0.05km (0.01km^2)

Receptor	Potential Impact	Criteria and threshold	Maximum predicted impact range (km) and area (km^2)			
			Monopile		Pin-pile	
			Starting hammer energy (400kJ)	Maximum hammer energy (4,000kJ)	Starting hammer energy (240kJ)	Maximum hammer energy (2,400kJ)
	PTS from cumulative SEL (including soft-start and ramp-up)	NMFS (2018) SEL_{cum} Weighted 185 dB re 1 µPa^{2}s	N/A	5.2km (54km^2)	N/A	7.1km (100km^2)

N/A = not applicable
** the largest impact area of 1,000km^2 is associated with the average depth location, while the largest impact range of 21km is associated with the worst-case location.*

PTS from First Strike of Soft-start

309. The estimated maximum area within which PTS could occur in harbour porpoise (***Figure 11.5***) is up to 1.04km^2 for the maximum starting hammer energy (400kJ) (***Table 11.28***). The estimated maximum area within which PTS could occur in grey and harbour seal is less than 0.01km^2 for the maximum starting hammer energy (400kJ) (***Table 11.28***).

310. The estimated maximum number of harbour porpoise that could potentially be at risk of PTS as a result of a single strike of 400kJ is up to 0.63 individuals (0.0002% of the North Sea MU reference population). The magnitude of the potential impact is assessed as **negligible** with 0.0002% or less of the reference population anticipated to be exposed to effect without mitigation (***Table 11.29***).

311. The estimated maximum number of grey and harbour seal that could potentially be at risk of PTS as a result of a single strike of 400kJ is up to 0.00001 grey seal and 0.000005 harbour seal. The magnitude of the potential effect on grey seal and harbour seal without any mitigation is assessed as **negligible**, with less than 0.00001% of the reference populations anticipated to be exposed to the effect (***Table 11.29***).

312. Mitigation, as outlined in ***section 11.3.3***, would reduce the number of marine mammals in the potential impact range for PTS from the first strike of the soft-start and therefore reduce the risk of PTS.

PTS from Single Strike at Maximum Hammer Energy

313. The estimated maximum areas (without mitigation) within which PTS could occur in harbour porpoise (***Figure 11.5***) is estimated to be 4.6km^2 and 4.1km^2 for the

maximum hammer energy applied for the monopile (4,000kJ) and pin-pile (2,400kJ), respectively (***Table 11.30***).

314. The magnitude of the potential impact without any mitigation is assessed as **negligible** for harbour porpoise, with up to 2.8 harbour porpoise, 0.0008% or less of the North Sea MU reference population anticipated to be exposed to the effect without mitigation (***Table 11.29***).

315. The estimated maximum areas (without mitigation) within which PTS could occur in grey and harbour seal is up to 0.01km^2 for both the maximum hammer energy applied for the monopile (4,000kJ) and for the pin-pile (2,400kJ) (***Table 11.28***).

316. Without any mitigation, the magnitude of the potential effect for grey seal is assessed as **negligible**, with up to 0.00001 grey seal, less than 0.00001% of the reference population anticipated to be exposed to the effect (***Table 11.29***).

317. Without any mitigation, the magnitude of the potential effect for harbour seal is assessed as **negligible**, with up to 0.000005 harbour seal, less than 0.00001% of the reference population anticipated to be exposed to the effect (***Table 11.29***).

318. Mitigation, as outlined in ***section 11.3.3***, would reduce the risk of PTS from a single strike of the maximum hammer energy applied.

Table 11.29 Maximum Number of Individuals (and % of Reference Population) that Could be at Risk of Permanent Auditory Injury (PTS) from a Single Strike

Receptor	Potential Impact	Criteria and threshold	Monopile with starting hammer energy of 400kJ		Pin-pile with maximum hammer energy of 2,400kJ		Monopile with maximum hammer energy of 4,000kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)[1]	Magnitude
Harbour porpoise	PTS without mitigation – single strike	NMFS (2018) unweighted SPL_{peak} 202 dB re 1 µPa	0.60 harbour porpoise (0.0002% NS MU) based on EA1N of 0.58/km^2. 0.63 harbour porpoise (0.0002% NS MU) based on SCANS-III density of 0.607/km^2.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	2.4 harbour porpoise (0.0007% NS MU) based on EA1N density of 0.58/km^2. 2.5 harbour porpoise (0.0007% NS MU) based on SCANS-III density of 0.607/km^2.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect without mitigation).	2.7 harbour porpoise (0.00075% NS MU) based on EA1N density of 0.58/km^2. 2.8 harbour porpoise (0.0008% NS MU) based on SCANS-III density of 0.607/km^2.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect without mitigation).
		NMFS (2018) SEL_{ss} weighted 155 dB re 1 µPa^{2}s	0.006 harbour porpoise (<0.00001% NS MU) based on EA1N of 0.58/km^2.	Permanent effect with negligible magnitude (less than 0.001% of the reference population	0.3 harbour porpoise (0.00008% NS MU) based on EA1N density of 0.58/km^2.	Permanent effect with negligible magnitude (less than 0.001% of the reference population	0.01 harbour porpoise (<0.00001% NS MU) based on EA1N density of 0.58/km^2.	Permanent effect with negligible magnitude (less than 0.001% of the reference population

Receptor	Potential Impact	Criteria and threshold	Monopile with starting hammer energy of 400kJ		Pin-pile with maximum hammer energy of 2,400kJ		Monopile with maximum hammer energy of 4,000kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)[1]	Magnitude
			0.006 harbour porpoise (<0.00001% NS MU) based on SCANS-III density of 0.607/km².	anticipated to be exposed to effect, without mitigation).	0.3 harbour porpoise (0.00008% NS MU) based on SCANS-III density of 0.607/km².	anticipated to be exposed to effect without mitigation).	0.01 harbour porpoise (<0.00001% NS MU) based on SCANS-III density of 0.607/km².	anticipated to be exposed to effect without mitigation).
Grey seal	PTS without mitigation – single strike	NMFS (2018) unweighted SPL_{peak} 218 dB re 1 µPa	0.00001 grey seal (<0.00001% ref pop; <0.00001% SE England MU) based on EA1N windfarm density of 0.001/km².	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	0.00001 grey seal (<0.00001% ref pop; <0.00001% SE England MU) based on EA1N windfarm density of 0.001/km².	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	0.00001 grey seal (<0.00001% ref pop; <0.00001% SE England MU) based on EA1N windfarm density of 0.001/km².	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).
		NMFS (2018) SEL_{ss} Weighted	0.00001 grey seal (<0.00001% ref pop; <0.00001% SE	Permanent effect with negligible magnitude (less than 0.001% of	0.00001 grey seal (<0.00001% ref pop; <0.00001% SE	Permanent effect with negligible magnitude (less than 0.001% of	0.00001 grey seal (<0.00001% ref pop; <0.00001% SE England MU)	Permanent effect with negligible magnitude (less than 0.001% of

Receptor	Potential Impact	Criteria and threshold	Monopile with starting hammer energy of 400kJ		Pin-pile with maximum hammer energy of 2,400kJ		Monopile with maximum hammer energy of 4,000kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)[1]	Magnitude
		185 dB re 1 µPa²s	England MU) based on EA1N windfarm density of 0.001/km².	the reference population anticipated to be exposed to effect, without mitigation).	England MU) based on EA1N windfarm density of 0.001/km².	the reference population anticipated to be exposed to effect, without mitigation).	based on EA1N windfarm density of 0.001/km².	the reference population anticipated to be exposed to effect, without mitigation).
Harbour seal	PTS without mitigation – single strike	NMFS (2018) unweighted SPL_{peak} 218 dB re 1 µPa	0.000005 harbour seal (<0.00001% ref pop; <0.00001% SE England MU) based on EA1N windfarm density of 0.0005/km².	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	0.000005 harbour seal (<0.00001% ref pop; <0.00001% SE England MU) based on EA1N windfarm density of 0.0005/km².	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	0.000005 harbour seal (<0.00001% ref pop; <0.00001% SE England MU) based on EA1N windfarm density of 0.0005/km².	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).
		NMFS (2018) SEL_{ss} Weighted	0.000005 harbour seal (<0.00001% ref pop; <0.00001% SE England MU)	Permanent effect with ***negligible*** magnitude (less than 0.001% of the reference	0.000005 harbour seal (<0.00001% ref pop; <0.00001% SE England MU)	Permanent effect with ***negligible*** magnitude (less than 0.001% of the reference	0.000005 harbour seal (<0.00001% ref pop; <0.00001% SE England MU)	Permanent effect with ***negligible*** magnitude (less than 0.001% of the reference

Receptor	Potential Impact	Criteria and threshold	Monopile with starting hammer energy of 400kJ		Pin-pile with maximum hammer energy of 2,400kJ		Monopile with maximum hammer energy of 4,000kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)[1]	Magnitude
		185 dB re 1 μPa²s	based on EA1N windfarm density of 0.0005/km².	population anticipated to be exposed to effect, without mitigation).	based on EA1N windfarm density of 0.0005/km².	population anticipated to be exposed to effect, without mitigation).	based on EA1N windfarm density of 0.0005/km².	population anticipated to be exposed to effect, without mitigation).

PTS from Cumulative Exposure

319. The range for Cumulative Sound Exposure Level (SEL_{cum}) for permanent auditory injury (PTS) is the distance an animal would need to be from the pile location to not be at risk of PTS from cumulative exposure.

320. SEL_{cum} determines the potential risk of PTS from the repeated percussive strikes. 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.

321. It is important to note that the PTS SEL_{cum} range can be significantly influenced by a number of parameters, including duration and strike rate during soft-start and ramp-up and at maximum hammer energy and swim speed. The SEL_{cum} results for pin piles are larger than those for monopiles, this is primarily because of the faster strike rate assumed for installing pin piles. The noise modelling and assessment has been conducted based on a precautionary worst-case approach.

322. The SEL_{cum} results for harbour porpoise using the NMFS (2018) criteria indicates that the predicted maximum impacted ranges for pin-piles is greater than for a monopile. This reflects the hearing sensitivity of harbour porpoise and the sound frequencies produced by the different pile. 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 11.4***).

323. As a result of the maximum pin-pile hammer energy of 2,400kJ, the estimated maximum number of harbour porpoise that could potentially be at risk of PTS from cumulative SEL is up to 607 harbour porpoise (0.18% of the reference population) (***Table 11.30***). The magnitude of the potential impact is assessed as medium, with between 0.01 and 1% of the reference population anticipated to be exposed to the effect. This assessment is without any further mitigation, as the embedded mitigation of the soft-start and ramp-up has been included in the modelling for PTS from cumulative exposure.

324. The modelling and assessments will be updated for the MMMP prior to construction, taking into account the pin-pile installation requirements, such as

soft-start and ramp-up duration, and the overall installation for single pin-pile and four pin-piles.

325. For grey and harbour seals, the maximum potential impact areas for PTS from cumulative SEL is 100km^2 for the maximum hammer energy applied of 2,400kJ for the installation of pin-piles. This is based on the total piling duration to install one pin-pile (including the soft-start and ramp-up) and the animals fleeing at a precautionary average speed of 1.5m/s (***Table 11.28***). A total of 0.1 grey seal and 0.05 harbour seal could be at risk of PTS (0.0005% and 0.0001% of the reference populations, respectively; ***Table 11.30***).

326. The magnitude of the potential effect on grey seal and harbour seal is assessed as negligible, with less than 0.001% of the reference populations anticipated to be exposed to the effect. This assessment is without any further mitigation, as the embedded mitigation of the soft-start and ramp-up has been included in the modelling for PTS from cumulative exposure.

327. It should be noted that assessment for PTS from cumulative exposure is highly precautionary for the following reasons:

- The maximum impact ranges provided in ***Appendix 11.4***, 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 location used within the modelling is for the worst-case water depth, with the worst-case surrounding bathymetry, which is unrealistic to the majority of the site (for example as presented in ***Appendix 11.4***, for harbour porpoise (high frequency cetacean) the maximum predicted impact range for PTS SEL_{cum} for monopile with maximum hammer energy of 4,000kJ was 6.4km, with a minimum range of 4.6km and a mean range of 5.5km for the worst-case location. At the average depth location, the maximum predicted impact range was 5.4km, with a minimum range of 3.5km and mean range of 4.6km);
- The maximum hammer energy expected to be applied has been used within the modelling. It is unlikely that maximum hammer energy and duration will be required at the majority of piling locations (see ***paragraphs 365*** to ***367***);
- 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 11.30 Indicative Maximum Number of Individuals (and % of Reference Population) that could be at Risk of PTS from Cumulative Exposure

Receptor	Potential Impact	Criteria and threshold	Monopile with maximum hammer energy of 4,000kJ		Pin-pile with maximum hammer energy of 2,400kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude
Harbour porpoise	PTS – cumulative exposure (including soft-start and ramp-up)	NMFS (2018) SEL_{cum} Weighted 155 dB re 1 μPa^2s	53 harbour porpoise (0.015% NS MU) based on EA1N of $0.58/km^2$. 56 harbour porpoise (0.016% NS MU) based on SCANS-III density of $0.607/km^2$.	Permanent effect with medium magnitude (between 0.01 and 1% of the reference population anticipated to be exposed to effect, without mitigation).	573 harbour porpoise (0.17% NS MU) based on EA1N of $0.58/km^2$. 607 harbour porpoise (0.18% NS MU) based on SCANS-III density of $0.607/km^2$.	Permanent effect with medium magnitude (between 0.01 and 1% of the reference population anticipated to be exposed to effect, without mitigation).
Grey seal	PTS – cumulative exposure (including soft-start and ramp-up)	NMFS (2018) SEL_{cum} Weighted 185 dB re 1 μPa^2s	0.054 grey seal (0.0002% ref pop; 0.0006% SE England MU) based on EA1N windfarm density of $0.001/km^2$.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	0.1 grey seal (0.0005% ref pop; 0.001% SE England MU) based on EA1N windfarm density of $0.001/km^2$	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).
Harbour seal	PTS – cumulative exposure (including soft-start and ramp-up)	NMFS (2018) SEL_{cum} Weighted 185 dB re 1 μPa^2s	0.03 harbour seal (0.00006% ref pop; 0.0005% SE England MU) based on EA1N windfarm density of $0.0005/km^2$.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).	0.05 harbour seal (0.0001% ref pop; 0.001% SE England MU) based on EA1N windfarm density of $0.0005/km^2$.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect, without mitigation).

11.6.1.3.2.3 Impact Significance

328. Taking into account the high receptor sensitivity and the potential magnitude of the effect (i.e. number of individuals as a percentage of the reference population), the impact significance for any permanent auditory injury (PTS) in harbour porpoise, grey seal and harbour seal from a single strike of the maximum or starting hammer energy for monopiles or pin-piles has been assessed as **minor adverse**. For cumulative exposure, harbour porpoise has been assessed as having a potential **major adverse** impact, and harbour and grey seal as having a **minor adverse** impact (***Table 11.31***).

Mitigation

329. As outlined in ***section 11.3.3***, 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. 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.

330. The proposed mitigation would reduce the risk of PTS from the first strike of the soft-start, single strike of the maximum hammer energy applied and cumulative PTS.

331. In addition, Brandt et al. (2018) found that at seven German offshore windfarms in the vicinity (up to 2km) of the construction site, harbour porpoise detections declined several hours before the start of piling as a result of increased construction related activities and vessels. This disturbance of harbour porpoise from the area around the construction site prior to piling would also reduce the risk of PTS.

Residual Impact

332. 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. Therefore, with high sensitivity, the potential impact significance for any permanent auditory injury will be **minor adverse** (not significant) (***Table 11.31***).

Table 11.31 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
PTS from single strike of starting hammer energy	Harbour porpoise	High	Negligible	Minor adverse	MMMP	**Minor adverse**
	Grey seal and harbour seal	High	Negligible	Minor adverse		**Minor adverse**
PTS from single strike of maximum hammer energy	Harbour porpoise	High	Negligible	Minor adverse		**Minor adverse**
	Grey seal and harbour seal	High	Negligible	Minor adverse		**Minor adverse**
PTS during piling from cumulative exposure	Harbour porpoise	High	Medium	Major adverse		**Minor adverse**
	Grey seal and harbour seal	High	Negligible	Minor adverse		**Minor adverse**

11.6.1.3.3 Temporary Auditory Injury (TTS)

11.6.1.3.3.1 Sensitivity

333. Harbour porpoise, grey seal and harbour seal are assessed as having medium sensitivity to TTS onset (***Table 11.27***). The sensitivity of each receptor to TTS onset is assumed to be the same as fleeing response / likely disturbance.

334. 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 disturbance'. 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 disturbance' range 100% of the individuals exposed to the noise stimulus will respond and flee the area.

11.6.1.3.3.2 Magnitude

335. The underwater noise modelling results for the maximum predicted ranges (and areas) for TTS and fleeing response in harbour porpoise, grey seal and harbour seal are presented in ***Table 11.32***.

Table 11.32 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 4,000kJ	Pin-pile with maximum hammer energy of 2,400kJ
TTS and fleeing response without mitigation – single strike	Harbour porpoise	NMFS (2018) unweighted SPL_{peak} 196 dB re 1 µPa	3.2km (31km^2)	3.1km (28km^2)
		NMFS (2018) SEL_{ss} weighted 140 dB re 1 µPa^2s	1.1km (3.9km^2)	5km (70km^2)
	Grey seal and harbour seal	NMFS (2018) unweighted SPL_{peak} 212 dB re 1 µPa	0.2km (0.12km^2)	0.19km (0.11km^2)
		NMFS (2018) SEL_{ss} weighted 170 dB re 1 µPa^2s	0.87km (2.4km^2)	0.87km (2.4km^2)
TTS from cumulative SEL	Harbour porpoise	NMFS (2018) SEL_{cum} Weighted 140 dB re 1 µPa^2s	27km (1,600km^2)	45km (4,200km^2)
	Grey seal and harbour seal	NMFS (2018) SEL_{cum} Weighted 170 dB re 1 µPa^2s	25km (1,400km^2)	28km (1,700km^2)

Table 11.33 Maximum Number of Individuals (and % of Reference Population) That Could be at Risk of Temporary Auditory Injury (TTS) / Fleeing Response from a Single Strike and Cumulative Exposure

Potential Impact	Receptor	Criteria and threshold	Monopile with maximum hammer energy of 4,000kJ		Pin-pile with maximum hammer energy of 2,400kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude
TTS / fleeing response – single strike	Harbour porpoise	NMFS (2018) SEL$_{ss}$ weighted 140 dB re 1 µPa^{2}s	2.4 harbour porpoise (0.0007% NS MU) based on SCANS-III density (0.607/km^2). 2.3 harbour porpoise (0.0007% NS MU) based on site specific survey density (0.58/km^2) at EA1N.	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).	42.5 harbour porpoise (0.012% NS MU) based on SCANS-III density (0.607/km^2). 40.6 harbour porpoise (0.012% NS MU) based on site specific survey density (0.58/km^2) at EA1N.	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).
	Grey seal	NMFS (2018) SEL$_{ss}$ weighted 170 dB re 1 µPa^{2}s	0.0024 grey seal (0.00001% ref pop; 0.00003% SE England MU) based on EA1N windfarm site density (0.001/km^2).	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).	0.0024 grey seal (0.00001% ref pop; 0.00003% SE England MU) based on EA1N windfarm site density (0.001/km^2).	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).
	Harbour seal	NMFS (2018) SEL$_{ss}$ weighted 170 dB re 1 µPa^{2}s	0.0012 harbour seal (0.000003% ref pop; 0.00002% SE England MU)	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be	0.0012 harbour seal (0.000003% ref pop; 0.00002% SE England MU) based on EA1N	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed

Potential Impact	Receptor	Criteria and threshold	Monopile with maximum hammer energy of 4,000kJ		Pin-pile with maximum hammer energy of 2,400kJ	
			Maximum number of individuals (% of reference population)	Magnitude	Maximum number of individuals (% of reference population)	Magnitude
			based on EA1N windfarm site density (0.0005/km²).	exposed to effect, without mitigation).	windfarm site density (0.0005/km²).	to effect, without mitigation).
TTS – cumulative exposure	Harbour porpoise	NMFS (2018) SEL_{cum} Weighted 140 dB re 1 µPa²s	971 harbour porpoise (0.28% NS MU) based on SCANS-III density (0.607/km²). 928 harbour porpoises (0.27% NS MU) based on site specific survey density (0.58/km²) at EA1N.	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).	2,549 harbour porpoises (0.74% NS MU) based on SCANS-III density (0.607/km²). 2,436 harbour porpoise (0.71% NS MU) based on site specific survey density (0.58/km²) at EA1N.	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).
	Grey seal	NMFS (2018) SEL_{cum} Weighted 170 dB re 1 µPa²s	1.4 grey seal (0.006% ref pop; 0.016% SE England MU) based on EA1N windfarm site density (0.001/km²).	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).	1.7 grey seal (0.008% ref pop; 0.019% SE England MU) based on EA1N windfarm site density (0.001/km²).	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to be exposed to effect, without mitigation).
	Harbour seal	NMFS (2018) SEL_{cum} Weighted	0.7 harbour seal (0.0016% ref pop; 0.014% SE England MU) based on	Temporary effect with negligible magnitude (less than 1% of the reference population	0.85 harbour seal (0.002% ref pop; 0.017% SE England MU) based on	Temporary effect with negligible magnitude (less than 1% of the reference population

Potential Impact	Receptor	Criteria and threshold	Monopile with maximum hammer energy of 4,000kJ		Pin-pile with maximum hammer energy of 2,400kJ	
			Maximum number of individuals (% of reference population)	**Magnitude**	**Maximum number of individuals (% of reference population)**	**Magnitude**
		170 dB re 1 µPa²s	EA1N windfarm site density (0.0005/km²).	anticipated to be exposed to effect, without mitigation).	EA1N windfarm site density (0.0005/km²).	anticipated to be exposed to effect, without mitigation).

TTS / Fleeing Response from Single Strike at Maximum Hammer Energy

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

337. The estimated maximum ranges for TTS / fleeing response in harbour porpoise is estimated to be 1.1km (SPL_{peak}) and 5km (SEL_{ss}) for the maximum hammer energy applied for the monopile (4,000kJ) and pin-pile (2,400kJ), respectively (***Figure 11.6***; ***Table 11.32***).

338. The magnitude of the potential impact for harbour porpoise is assessed as **negligible**, with 0.012% or less the reference population anticipated to be exposed to the temporary effect (***Table 11.33***).

339. The estimated maximum ranges within which TTS / fleeing response could occur in grey and harbour seal is up to 0.87km (SEL_{ss}) for the maximum hammer energy applied for the monopile (4,000kJ) and pin-pile (2,400kJ) (***Figure 11.7***; ***Table 11.32***).

340. The magnitude of the potential effect on grey and harbour seal is assessed as **negligible**, with 0.0001% or less the reference populations anticipated to be exposed to the temporary effect (***Table 11.33***).

TTS from Cumulative Exposure

341. The ranges at which an individual could experience TTS 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 27km and 45km for harbour porpoise for the maximum hammer energies applied of 4,000kJ for monopiles and 2,400kJ for pin-piles, respectively, based on the NOAA (NMFS 2018) criteria (***Table 11.32***).

342. The indicative maximum number of harbour porpoise that could potentially be at risk of TTS from cumulative SEL as a result of the maximum monopile hammer energy of 4,000kJ is up to 971 individuals (0.28% of the North Sea MU reference population) (***Table 11.33***). The magnitude of the potential impact is assessed as negligible, with 0.28% or less of the reference population anticipated to be exposed to the temporary effect.

343. For pin-piles with maximum hammer energy to be applied of 2,400kJ, the indicative maximum number of harbour porpoise that could potentially be at risk of TTS from cumulative SEL is up to 2,549 harbour porpoise (0.74% of the North Sea MU reference population). The magnitude of the potential impact is

assessed as negligible, with 0.74% or less of the reference population anticipated to be exposed to the temporary effect (***Table 11.33***).

344. For grey and harbour seals, the maximum potential impact ranges for TTS from cumulative SEL is 25km for the maximum hammer energy to be applied of 4,000kJ for monopiles and 28km for the maximum hammer energy to be applied of 2,400kJ for pin-piles (***Table 11.32***).

345. The magnitude of the potential effect on grey and harbour seal is assessed as negligible, with 0.008% and 0.002% or less of the reference populations respectively anticipated to be exposed to the temporary effect (***Table 11.33***).

346. As outlined for PTS from cumulative exposure, the ranges indicate the distance that an individual would need 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, as discussed for cumulative PTS, 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.

11.6.1.3.3.3 Impact Significance

347. 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** (***Table 11.34***).

348. The mitigation to reduce the risk of PTS (as outlined in ***section 11.3.3***) will move animals away from the piling location and will therefore also reduce the number of animals in the predicted impact area for TTS.

349. The residual impact of the potential risk of temporary auditory injury (TTS) to marine mammals as a result of underwater noise during piling, taking into account the MMMP for piling, is expected that the overall impact significance will be **minor adverse** (***Table 11.34***).

Table 11.34 Assessment of Impact Significance for any Temporary Auditory Injury (TTS) in Marine Mammals from Underwater Noise During Piling

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
TTS / fleeing response from single strike of maximum hammer energy	Harbour porpoise	Medium	Negligible	Minor adverse	MMMP for piling	**Minor adverse**
	Grey seal and harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
TTS during piling from cumulative exposure	Harbour porpoise	Medium	Negligible	Minor adverse		**Minor adverse**
	Grey seal and harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**

11.6.1.4 Impact 4: Behavioural Impacts Resulting from Underwater Noise During Piling

350. Marine mammals may exhibit varying intensities of behavioural response at different 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. 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).

11.6.1.4.1 Disturbance

11.6.1.4.1.1 Sensitivity

351. 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. Harbour porpoise are assessed as having medium sensitivity to disturbance (***Table 11.27***).

352. Grey seal and harbour seal exhibit alternate periods of foraging and resting at haul out sites (during which limited or no feeding occurs). Prolonged fasting also occurs in these species during annual breeding and moult, when there are marked seasonal changes in body condition (Rosen and Renouf 1997; Bäcklin et al. 2011). Although adult seals may be relatively robust to short term (weeks rather than days 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 Lincs 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 11.27***).

353. 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 (***Table 11.8***).

11.6.1.4.1.2 Magnitude

354. 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 in harbour porpoise, grey seal and harbour seal are presented in ***Table 11.32***, with the estimated number and percentage of reference populations in ***Table 11.33***.

355. 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 disturbance range, as outlined below, 100% of the individuals exposed to the noise stimulus will respond and be displaced from the area. However, it is unlikely that all individuals would be displaced from the potential disturbance area, therefore this a very precautionary approach.

Disturbance During Proposed Mitigation

356. During the implementation of the proposed mitigation, for example the activation of ADDs for 10 minutes, it is estimated that animals would move at least 0.9km from the piling location (based on a precautionary marine mammal swimming speed of 1.5m/s), resulting in a potential disturbance area of 2.54km^2.

357. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation would be 1.5 individuals (0.0004% of the North Sea MU reference population), based on the SCANS-III density (0.607 harbour porpoise per km^2) as a worst-case. Less than 1% of the reference population would be temporarily exposed to the effect. Therefore, the magnitude of the potential temporary impact is assessed as negligible.

358. The number of grey seal that could potentially be disturbed as a result of the proposed mitigation would be 0.003 individuals (0.00001% of the reference population or 0.00003% of the South-east England MU), based on the East Anglia ONE North windfarm site density (0.001/km^2). Therefore, the magnitude of the potential temporary impact is assessed as negligible.

359. The number of harbour seal that could potentially be disturbed as a result of the proposed mitigation would be 0.001 individuals (0.000003% of the reference population or 0.00003% of the South-east England MU), based on the East Anglia ONE North windfarm site density (0.00005/km^2). Therefore, the magnitude of the potential temporary impact is assessed as negligible.

360. 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.

Disturbance During Single Pile Installation

361. The current advice from the SNCBs is that a potential disturbance range of 26km (2,124km^2) around piling locations is used to assess the area that harbour porpoise may be disturbed in the SNS SAC. The East Anglia ONE North offshore development area is located within the SNS SAC, 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 11.35***.

362. Data from tagged harbour seals in the Wash indicate that seals were not excluded from the vicinity of Lincs Offshore Wind Farm 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 (***Table 11.35***). It is acknowledged that this is not Natural England's advice; however, this approach was agreed by the ETG.

363. The estimated maximum numbers of harbour porpoise, grey seal and harbour seal that could potentially be disturbed as a result of underwater noise from piling are shown in ***Table 11.35***. For each species, 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.

Table 11.35 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	% of reference population	Magnitude
Area of disturbance (2,124km^2) from underwater noise during piling	Harbour porpoise	1,289 harbour porpoise based on SCANS-III survey density (0.607/km^2). 1,232 harbour porpoise based on the East Anglia ONE North windfarm site specific survey density (0.58/km^2).	0.4% of NS MU based on SCANS-III density. 0.35% of NS MU based on site specific survey density.	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
	Grey seal	2 grey seal based on density in the EA1N windfarm site (0.001/km^2).	0.01% ref pop (0.02% SE England MU)	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
	Harbour seal	1 harbour seal based on density in the EA1N windfarm site (0.0005/km^2).	0.002% ref pop (0.02% SE England MU)	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).

364. The maximum duration of potential disturbance for active piling (including soft start and ramp-up) would be 35.2 days within the 27 month offshore construction period. 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.

365. The duration of piling is based on a worst-case scenario and a very precautionary approach and as has been shown at other offshore windfarms, the duration used in the impact assessment can be overestimated. For example, during the installation of monopile foundations at the Dudgeon Offshore Windfarm (DOW) the impact assessment was based on an estimated time to install each monopile of 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; approximately 21% of the predicted maximum piling duration (DOWL 2016).

366. Similar results were observed for the more recently constructed Beatrice Offshore Wind Farm, where within the ES it was estimated that each pin-pile would require 5 hours of active piling time and that the maximum hammer energy would be 2,300kJ (Beatrice Offshore Wind Farm Ltd 2018). During construction, the maximum hammer energy required ranged between 435kJ and 2,299kJ, with an average across the site of 1,088kJ. The total duration of piling ranged from 19 minutes to 2 hours and 45 minutes, with an average duration of 1 hour and 15 minutes per pile (Beatrice Offshore Wind Farm Ltd 2018).

367. The East Anglia ONE Offshore Windfarm piling logs for the first four piles indicate that the maximum hammer energy used was 935kJ for one pile, or 78% of the operational limit of 1,200kJ. The average hammer energy used over these first four piles was 787kJ, or 66% of the 1,200kJ limit (East Anglia ONE Ltd, 2019). This pattern is also shown for the remainder of the piling logs, with 56.5% of all the piled foundations using 70% or less of the 1,200kJ limit (or less than 840kJ), a further 36% of the foundations using between 70 and 80% of the 1,200kJ limit (or less than 960kJ), and 7.5% of all foundations using above 80% of the 1,200kJ operational limit for hammer energy (or above 960kJ), with only one piled foundation nearing this limit (1,132kJ) (taken from the Actual Pile Driving Energies Technical Note for East Anglia ONE Offshore Windfarm).

368. 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.

369. A study on the effects of the construction of offshore windfarms within the German North Sea between 2009 and 2013 on harbour porpoise (Brandt et al. 2016) concluded that although there were clear negative short-term effects (1-2 days in duration) of offshore windfarm 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 windfarm construction at the population level (Brandt et al. 2016).

370. Nabe-Nielsen et al. (2018) developed the DEPONS (Disturbance Effects of Noise on the Harbour Porpoise Population in the North Sea) model to simulate individual animal's movements, energetics and survival for assessing population consequences of sub-lethal behavioural effects. The model was used to assess the impact of offshore windfarm construction noise on the North Sea harbour porpoise population, based on the acoustic monitoring of harbour porpoise during construction of the Dutch Gemini offshore windfarm. Local population densities around the Gemini windfarm recovered 2–6 hours after piling, similar recovery rates were obtained in the model. The model indicated that, assuming noise influenced porpoise movements as observed at the Gemini windfarm, the North Sea harbour porpoise population was not affected by construction of 65 wind farms, as required to meet the EU renewable energy target (Nabe-Nielsen et al. 2018).

371. The DEPONS model determined that at the North Sea scale, population dynamics were indistinguishable from those in the noise-free baseline scenario when porpoises reacted to noise up to 8.9km from the construction sites, as at the Gemini windfarm. Underwater noise from offshore windfarm construction noise only influenced population dynamics in the North Sea when simulated animals were assumed to respond at distances exceeding 20–50km from the windfarms. Indicating that in these scenarios, the population effect of noise was more strongly related to the distance at which animals reacted to noise (Nabe-Nielsen et al. 2018).

372. The duration of any potential displacement effect will differ depending on the distance of the individual from the piling activity and the noise level to which the animal is exposed.

11.6.1.4.1.3 Impact Significance

373. 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 11.36***).

374. In addition to the MMMPs for piling, if required, an East Anglia ONE North SNS SAC SIP will be developed (***section 11.3.3***). The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SNS SAC, in particular in relation to the disturbance of harbour porpoise. Any measures put in place to reduce the effects on harbour porpoise would also reduce any impacts on grey and harbour seal.

Table 11.36 Assessment of Impact Significance for Disturbance of Marine Mammals as a Result of Underwater Noise During Piling

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Disturbance as a result of underwater noise during piling for single installation (2,124km^2)	Harbour porpoise	Medium	Negligible	Minor adverse	For example, a SIP.	Minor adverse
	Grey seal	Medium	Negligible	Minor adverse		Minor adverse
	Harbour seal	Medium	Negligible	Minor adverse		Minor adverse

11.6.1.4.2 Possible Behavioural Response in Harbour Porpoise

11.6.1.4.2.1 Sensitivity

375. 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. Not all individuals that are exposed to this level of noise will respond.

376. The sensitivity of harbour porpoise to this type of effect is considered to be low, as not all individuals will respond (***Table 11.27***).

11.6.1.4.2.2 Magnitude

377. Based on the unweighted Lucke et al. (2009) criteria (unweighted SEL_{ss} of 145 dB re 1 µPa^2s), the estimated maximum range which could result in a possible behavioural response by harbour porpoise is estimated to be up to 46km for both the maximum hammer energy applied for the monopile (4,000kJ) and pin-pile (2,400kJ), respectively (***Appendix 11.4***).

378. 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).

379. 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 applied, 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.

380. The estimated number of harbour porpoise that could potentially exhibit a possible behavioural response as a result of a single strike of the maximum hammer energy for monopiles or pin-piles is up to 1,487 individuals (up to 0.43% of the reference population) based on 50% of the harbour porpoise in the maximum predicted area responding (***Table 11.37***). The magnitude of the potential effect is assessed as negligible with between 0.40% and 0.86% of the reference population anticipated to respond.

381. As outlined above, 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.

11.6.1.4.2.3 Impact Significance

382. 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 possible behavioural response in harbour porpoise has been assessed as **negligible** (***Table 11.37***).

383. As outlined in ***section 11.3.3.3.3***, if required, a SIP will set out the approach to deliver any project mitigation related to management measures for the SNS SAC.

Table 11.37 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	% of reference population	Estimated number based on 75% of individuals in area responding	% of reference population	Estimated number based on 50% of individuals in area responding	% of reference population	Magnitude
Possible behavioural response to underwater noise during piling – maximum hammer energy for monopile (4,900km²)	2,974 harbour porpoise based on SCANS-III density (0.607/km²).	0.86% of NS MU based on SCANS-III density.	2,230.5 harbour porpoise based on SCANS-III density (0.607/km²).	0.65% of NS MU based on SCANS-III density.	1,487 harbour porpoise based on SCANS-III density (0.607/km²).	0.43% of NS MU based on SCANS-III density.	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to respond).
	2,842 harbour porpoise based on EA1N survey density (0.58/km²).	0.82% of NS MU based on EA1N survey density.	2,131.5 harbour porpoise based on EA1N survey density (0.58/km²).	0.62% of NS MU based EA1N survey density.	1,421 harbour porpoise based on EA1Nsurvey density (0.58/km²).	0.41% of NS MU based on EA1N survey density.	
Possible behavioural response to underwater noise during piling – maximum hammer energy for pin-pile (4,800km²)	2,914 harbour porpoise based on SCANS-III density (0.607/km²).	0.84% of NS MU based on SCANS-III density.	2,185.5 harbour porpoise based on SCANS-III density (0.607/km²).	0.63% of NS MU based on SCANS-III density.	1,457 harbour porpoise based on SCANS-III density (0.607/km²).	0.42% of NS MU based on SCANS-III density.	Temporary effect with negligible magnitude (less than 1% of the reference population anticipated to respond).
	2,784 harbour porpoise based on EA1N survey density (0.58/km²).	0.81% of NS MU based on EA1N survey density.	2,088 harbour porpoise based on EA1Ndensity (0.58/km²).	0.60% of NS MU based on EA1N survey density.	1,392 harbour porpoise based on EA1N survey density (0.58/km²).	0.40% of NS MU based on EA1N survey density.	

Table 11.38 Assessment of Impact Significance for Possible Behavioural Response of Harbour Porpoise as a result of Underwater Noise During Piling

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Possible behavioural response to underwater noise during piling	Harbour porpoise	Low	Negligible	Negligible	For example, a SIP.	**Negligible**

11.6.1.5 Impact 5: Potential Impacts Resulting from Underwater Noise During Other Construction Activities

384. This section assesses the potential impacts that could be associated with underwater noise during construction activities, other than pile driving. Noise associated with vessels is assessed in ***section 11.6.1.6***. Potential sources of underwater noise during non-piling construction activities include seabed preparation, dredging, rock dumping, trenching and cable installation (ploughing; jetting; and trenching or cutting) (***Table 11.2***).

385. 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).

386. 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.

387. 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 (Central Dredging Association (CEDA) 2011, World Organisation of Dredging Associations (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 that for a cargo ship travelling at modest speed (between 8 and 16 knots) (Theobald et al. 2011).

388. 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.

389. 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 as a result of exposure to noise (Southall et al. 2007).

390. 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 and 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).

11.6.1.5.1 Sensitivity

391. 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, while the sensitivity of marine mammals to permanent auditory injury (PTS) is considered to be high and the sensitivity of harbour porpoise for possible behavioural response is low.

392. Marine mammals within the potential disturbance area are considered to have limited capacity to avoid such effects (***Table 11.8***), 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.

11.6.1.5.2 Magnitude

393. Underwater noise modelling was undertaken to assess the impact ranges of non-piling construction activities on marine mammals, and this has been used to determine the potential impact on marine mammal species. The underwater noise propagation modelling was undertaken using a simple modelling approach

for a number of offshore construction activities; using measured sound source data scaled to relevant parameters for the East Anglia ONE North windfarm site (see ***Appendix 11.4*** for further information). The activities that were assessed include:

- Dredging (estimated sound source of 186dB re 1µPs @1m): a TSHD may be required for the export cable and array cable installation;
- Drilling (estimated sound source of 179dB re 1µPs @1m): drilling of the foundations may need to be undertaken in the case of impact piling refusal;
- Cable laying (estimated sound source of 171dB re 1µPs @1m);
- Rock placement (estimated sound source of 172dB re 1µPs @1m): this is potentially required during offshore cable installation and scour protection; and
- Trenching (estimated sound source of 172dB re 1µPs @1m): plough trenching may be required during the export cable installation.

394. The results of the underwater noise modelling show that at the source levels predicted for the listed activities, any marine mammal would have to remain in close proximity (i.e. less than 3m for dredging activities, and less than 1m for other activities) of the sound source for 24 hours to be exposed to levels of sound that are sufficient to induce PTS as per the NMFS (2018) threshold criteria. ***Table 11.39*** shows the modelled results and areas of potential impact.

395. The number of harbour porpoise, grey seal and harbour seal that could be disturbed as a result of underwater noise during non-piling construction activities has been assessed based on the number of animals that could be present in each of the modelled impact ranges for the other construction activities as listed in ***Table 11.40***.

Table 11.39 Maximum Predicted Impact Ranges (and Areas) for Permanent Auditory Injury (PTS), Temporary Auditory Injury (TTS)/ Fleeing Response and for Possible Behavioural Response from Non-Piling Construction Activities Based on Underwater Noise Modelling

Potential Impact	Receptor	Criteria and threshold	The modelled impact ranges (km) (and areas* (km^2) for each offshore construction activity				
			Dredging	Drilling	Cable Laying	Rock Placement	Trenching
Permanent auditory injury (PTS) from cumulative SEL, based	Harbour porpoise	NMFS (2018) 173 dB re 1 µPa^{2}s HF SEL_{cum}	<0.1km (0.031km^2)	<0.1km (0.031km^2)	<0.1km (0.031km^2)	<0.1km (0.031km^2)	<0.1km (0.031km^2)

Potential Impact	Receptor	Criteria and threshold	The modelled impact ranges (km) (and areas* (km^2) for each offshore construction activity				
			Dredging	Drilling	Cable Laying	Rock Placement	Trenching
on 24 hour exposure	Grey and Harbour seal	NMFS (2018) 201 dB re 1 µPa²s PW SEL_{cum}	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)
Temporary auditory injury (TTS) / fleeing response from cumulative SEL, based on 24 hour exposure	Harbour porpoise	NMFS (2018) 153 dB re 1 µPa²s HF SEL_{cum}	0.23km ($0.17km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	0.99km ($3.08km^2$)	<0.1km ($0.031km^2$)
	Grey and Harbour seal	NMFS (2018) 181 dB re 1 µPa²s PW SEL_{cum}	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)	<0.1km ($0.031km^2$)
Possible behavioural response to underwater noise during other construction activities	Harbour porpoise	Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa	0.15km ($0.071km^2$)	0.13km ($0.053km^2$)	0.11km ($0.038km^2$)	0.18km ($0.1km^2$)	0.12km ($0.045km^2$)

**Maximum area based on area of circle with maximum impact range for radius as worst-case scenario*

396. The magnitude of the potential impact of permanent auditory injury (PTS), temporary auditory injury (TTS) / fleeing response and possible behavioural response as a result of non-piling construction noise is negligible for harbour porpoise, grey seal and harbour seal, with 0.00001% or less of the reference populations likely to be affected for any permanent impacts (PTS), and less than 1% temporarily disturbed (***Table 11.40***).

397. 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 the 27 month construction period and would be limited to only part of the overall construction period and area.

Table 11.40 Maximum Number of Individuals (and % of Reference Population) that Could be Impacted as a Result of Underwater Noise Associated with Non-Piling Construction Activities Based on Underwater Noise Modelling

Potential Impact	Receptor	Criteria and Threshold	Estimated number in impact area (% of reference population)	Magnitude
PTS from Dredging, or Drilling, or Cable Laying, or Rock Placement, or Trenching	Harbour porpoise	PTS from cumulative SEL, based on 24 hour exposure NMFS (2018) 173 dB re 1 µPa²s (0.031km²)	0.02 harbour porpoise (0.000006% of the reference population) based on SCANS-III survey density (0.607/km²). 0.02 harbour porpoise (0.000006% of the reference population) based on site survey density (0.58/km²).	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect).
TTS / fleeing response from Dredging	Harbour porpoise	NMFS (2018) 153 dB re 1 µPa²s HF SEL_{cum} (0.17km²)	0.1 harbour porpoise (0.00003% of the reference population) based on SCANS-III survey density (0.607/km²). 0.1 harbour porpoise (0.00003% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
TTS / fleeing response from Drilling, or Cable laying, or Trenching	Harbour porpoise	NMFS (2018) 153 dB re 1 µPa²s HF SEL_{cum} (0.031km²)	0.02 harbour porpoise (0.000006% of the reference population) based on SCANS-III survey density (0.607/km²). 0.02 harbour porpoise (0.000006% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).

Potential Impact	Receptor	Criteria and Threshold	Estimated number in impact area (% of reference population)	Magnitude
TTS / fleeing response from Rock placement	Harbour porpoise	NMFS (2018) 153 dB re 1 µPa²s HF SEL_{cum} (3.08km²)	1.9 harbour porpoise (0.0006% of the reference population) based on SCANS-III survey density (0.607/km²) 1.8 harbour porpoise (0.0005% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
Possible behavioural response from Dredging	Harbour porpoise	Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa Possible behavioural response (0.071km²)	0.04 harbour porpoise (0.00001% of the reference population) based on SCANS-III density (0.607/km²). 0.04 harbour porpoise (0.00001% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
Possible behavioural response from Drilling		Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa Possible behavioural response (0.053km²)	0.03 harbour porpoise (0.000009% of the reference population) based on SCANS-III survey density (0.607/km²). 0.03 harbour porpoise (0.000009% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
Possible behavioural response from Cable laying		Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa Possible behavioural response (0.038km²)	0.02 harbour porpoise (0.000006% of the reference population) based on SCANS-III survey density (0.607/km²). 0.02 harbour porpoise (0.000006% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
Possible behavioural response from		Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa	0.06 harbour porpoise (0.00002% of the reference population) based on SCANS-III survey density (0.607/km²).	Temporary effect with negligible magnitude (less than 1% of reference

Potential Impact	Receptor	Criteria and Threshold	Estimated number in impact area (% of reference population)	Magnitude
Rock placement		Possible behavioural response (0.1km²)	0.06 harbour porpoise (0.00002% of the reference population) based on EA1N survey density (0.58/km²).	population likely to be affected).
Possible behavioural response from Trenching		Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa Possible behavioural response (0.045km²)	0.03 harbour porpoise (0.000009% of the reference population) based on SCANS-III survey density (0.607/km²). 0.03 harbour porpoise (0.000009% of the reference population) based on EA1N survey density (0.58/km²).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
PTS from Dredging, or Drilling, or Cable Laying, or Rock Placement, or Trenching	Grey seal	PTS from cumulative SEL, based on 24 hour exposure NMFS (2018) 201 dB re 1 µPa²s (0.031km²)	0.001 grey seal (0.000004% ref pop; 0.00001% SE England MU) based on density (0.03/km²) in the development area.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect).
	Harbour seal		0.0002 harbour seal (0.0000006% ref pop; 0.000005% SE England MU) based on density (0.007/km²) in the development area.	Permanent effect with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect).

Potential Impact	Receptor	Criteria and Threshold	Estimated number in impact area (% of reference population)	Magnitude
TTS from Dredging, or Drilling, or Cable Laying, or Rock Placement, or Trenching	Grey seal	NMFS (2018) 181 dB re 1 µPa²s PW SEL_{cum} (0.031km²)	0.0009 grey seal (0.000004% ref pop; 0.00001% SE England MU) based on density (0.03/km²) in the development area.	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
	Harbour seal		0.0002 harbour seal (0.0000006% ref pop; 0.000005% SE England MU) based on density (0.008/km²) in the development area.	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).

11.6.1.5.3 Impact Significance

398. Taking into account the high receptor sensitivity and the potential magnitude of the effect (i.e. number of individuals as a percentage of the reference population), the impact significance for permanent auditory injury (PTS) in harbour porpoise, grey seal and harbour seal from other construction activities has been assessed as **minor adverse** (***Table 11.41***); therefore, no further mitigation measures are proposed in ***section 11.3.3***.

399. Taking into account the medium receptor sensitivity, the potential magnitude of the effect and the temporary nature TTS / fleeing response, the impact significance for harbour porpoise, grey seal and harbour seal has been assessed as **minor adverse** (***Table 11.41***); therefore no further mitigation measures are proposed.

400. Taking into account the low receptor sensitivity, the potential magnitude of the effect, and the temporary nature of possible behavioural response, the impact significance for harbour porpoise has been assessed as **negligible** (***Table 11.41***); therefore, no further mitigation measures are proposed.

401. It should be noted that non-piling construction activities underway at the same time as piling, are not cumulative impacts. As the maximum potential impact areas for non-piling construction activities are less than those assessed for piling, they will therefore be included in the predicted disturbance impact area assessed for piling and will not increase the disturbance area.

402. The confidence in the data used in this assessment is medium and the level of precaution is high.

Table 11.41 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
Permanent auditory injury (PTS) from cumulative SEL during other construction activities	Harbour porpoise	High	Negligible	Minor adverse	No mitigation required	**Minor adverse**
	Grey seal	High	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	High	Negligible	Minor adverse		**Minor adverse**
Temporary auditory injury	Harbour porpoise	Medium	Negligible	Minor adverse		**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
(TTS) / fleeing response from cumulative SEL during other construction activities	Grey and harbour seal	Medium	Negligible	Minor adverse	No mitigation required	**Minor adverse**
Possible behavioural response to underwater noise during other construction activities	Harbour porpoise	Low	Negligible	Negligible	No mitigation required	**Negligible**

11.6.1.6 Impact 6: Underwater Noise and Disturbance from Construction Vessels

403. During the construction phase, there will be an increase in the number of vessels associated with installation of the wind turbine and platform foundations, cables and other infrastructure. Vessel movements to and from any port would be expected to be incorporated within existing vessel routes. Therefore, any disturbance as a result of increase in underwater noise from construction vessels is only likely to occur within the offshore development area.

404. The large construction 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.

405. As outlined in ***section 11.6.1.3.2.3***, Brandt et al. (2018) found that at seven German offshore wind farms, in the vicinity (up to 2km) of the construction site, harbour porpoise detections declines several hours before the start of piling as a result of increased construction related activities and vessels.

406. 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).

407. ***Chapter 14 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. During the summer survey, an average of 116 vessels per day passed within the shipping and navigation study area, recorded on AIS and Radar. During winter, this dropped to an average of 101 vessels per day. The majority of this traffic was comprised of cargo vessels (42% during summer and 47% in winter) and tankers (30% during summer and 40% in winter).

408. The approximate number of vessels on site at any one time during construction is estimated to be 74 vessels, with an estimated average of 124 trips per month, approximately 4.1 trips per day (***Table 11.2***). This could therefore represent up to a 3.5% increase in the number of vessels during the summer period and 4.1% increase in the number of vessels during the winter periods, compared to current baseline vessel numbers.

409. The approximate number of 74 vessels at any one time in the East Anglia ONE North offshore development area (approximately 0.2 vessels per km^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 (approximately 16 vessels per km^2). Based on the precautionary worst-case scenario, including existing vessel movements in and around the offshore development area, 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.

11.6.1.6.1 Sensitivity

410. 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[3].

411. Wisniewska et al. (2018) studied the change in foraging rates of harbour porpoise in response to vessel noise. Wideband sound and movement recording tags

[3] These calculations are valid for ambient noise levels typical for the German Bight / North Sea at wind-speeds between 3 and 8m/s.

were deployed on seven harbour porpoise to determine foraging rates as a function of the vessel noise present at that time. Tagged individuals were exposed to vessel noise between 17 and 89% of the time, with results showing that foraging was interrupted in the presence of high noise levels. Results show that a harbour porpoise stopped producing foraging echolocation clicks immediately when vessel noise became audible in the recording, seven minutes prior to the closest approach of the vessel which was 140m. This was estimated to be 7km from the individual based on known vessel speeds. Regular foraging activity resumed 8 minutes after the closest approach of the vessel, 15 minutes after initial exposure. Significantly fewer foraging echolocation clicks were made in minutes where vessel noise was at 96 dB re 1 µPa for three of the individuals and at 102 dB re 1 µPa for one individual. In addition, high vessel noise was incidentally associated with vigorous fluking, bottom diving and the cessation of echolocation completely. Therefore, if the exposure to vessel noise at over 96 dB re 1µPa is prolonged, there is the potential for reduced foraging activity (Wisniewska et al. 2018).

412. Given the 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.

413. 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 also considered to have a low sensitivity to vessel noise.

414. The sensitivity of marine mammals to permanent auditory injury (PTS) is considered to be high, medium for temporary auditory effects (TTS) / fleeing response and is considered to be low for the possible avoidance of harbour porpoise.

11.6.1.6.2 Magnitude

415. Underwater noise modelling was undertaken to assess the potential impact ranges of vessels on marine mammals (***Appendix 11.4***), and this is used to determine the impact on harbour porpoise, grey seal and harbour seal.

416. As outlined in ***section 11.6.1.5***, the underwater noise propagation modelling was undertaken using a simple modelling approach for underwater noise associated with both medium and large sized vessels, using measured sound source data scaled to relevant parameters for the East Anglia ONE North offshore

development area. The sound sources for vessels modelled were 171dB re 1µPs @1m for large vessels and 164dB re 1µPs @1m for medium vessels.

417. The results of the underwater noise modelling show that at the source levels predicted for the listed activities, any marine mammal would have to remain in close proximity (i.e. less than 100m) of the vessel for 24 hours to be exposed to levels of sound that are sufficient to induce PTS based on the NMFS (2018) threshold criteria (***Table 11.42***).

Table 11.42 Maximum Predicted Impact Ranges (and Areas) for Permanent Auditory Injury (PTS), Temporary Auditory Injury (TTS) / Fleeing Response and Possible Behavioural Response from Vessels

Potential Impact	The modelled impact ranges (km) (and areas* (km^2) for vessel noise			
	Receptor	Threshold and criteria	Vessels (Large)	Vessels (Medium)
Permanent auditory injury (PTS) from cumulative SEL from vessels, based on 24 hour exposure	Harbour porpoise	NMFS (2018) 173 dB re 1 µPa^2s	<0.1km (<0.031km^2)	<0.1km (<0.031km^2)
	Grey and Harbour seal	NMFS (2018) 201 dB re 1 µPa^2s	<0.1km (<0.031km^2)	<0.1km (<0.031km^2)
Temporary auditory injury (TTS) / fleeing response from cumulative SEL from vessels during construction, based on 24 hour exposure	Harbour porpoise	NMFS (2018) 153 dB re 1 µPa^2s	<0.1km (<0.031km^2)	<0.1km (<0.031km^2)
	Grey and Harbour seal	NMFS (2018) 181 dB re 1 µPa^2s	<0.1km (<0.031km^2)	<0.1km (<0.031km^2)
Possible behavioural response to underwater noise from vessels	Harbour porpoise	Lucke et al., (2009) Unweighted SEL 145 dB re 1 µPa	0.15km (0.071km^2)	<0.05km (0.0079km^2)

**Maximum area based on area of circle with maximum impact range for radius as worst-case scenario*

418. The number of harbour porpoise, grey seal and harbour seal that could be disturbed as a result of underwater noise during construction from vessels has been assessed based on the number of animals that could be present in the modelled impact ranges for large vessels as a worst-case scenario (***Table 11.43***).

419. The magnitude of the potential impact of any auditory injury (PTS or TTS) or disturbance as a result of construction vessel noise is **negligible** for harbour

porpoise, grey seal and harbour seal with less than 0.001% of the population likely to be impacted by permanent effects (PTS) and less than 1% of the reference population likely to be temporarily disturbed (***Table 11.44***).

Table 11.43 Maximum Number of Individuals (and % of Reference Population) that could be Impacted as a Result of Underwater Noise Associated with Vessels

Receptor	Potential Impact (area km^2)	Criteria and Threshold	Estimated number in impact area (% of reference population)	Magnitude
Harbour porpoise	Large vessels x 74 ($2.3km^2$)	NMFS (2018) 173 dB re 1 μPa^2s PTS from cumulative SEL And NMFS (2018) 153 dB re 1 μPa^2s TTS from cumulative SEL	1.4 harbour porpoise (0.0004% of the reference population) based on SCANS-III survey density ($0.607/km^2$). 1.3 harbour porpoise (0.0004% of the reference population) based on EA1N survey density ($0.58/km^2$).	Negligible for PTS (permanent effect with less than 0.001% of reference population likely to be affected). Negligible for TTS (temporary effect with less than 1% of reference population likely to be affected).
	Large vessels x74 ($5.25km^2$)	Lucke et al. (2009) Unweighted SEL 145 dB re 1 μPa Possible behavioural response	3.2 harbour porpoise (0.0009% of the reference population) based on SCANS-III survey density ($0.607/km^2$). 3 harbour porpoise (0.0009% of the reference population) based on EA1N survey density ($0.58/km^2$).	Temporary effect with negligible magnitude (less than 1% of reference population likely to be affected).
Grey seal	Large vessels x 74 ($2.3km^2$)	NMFS (2018) 201 dB re 1 μPa^2s PTS from cumulative SEL And NMFS (2018) 181 dB re 1 μPa^2s TTS from cumulative SEL	0.07 grey seal (0.0003% ref pop; 0.0008% SE England MU) based on density ($0.03/km^2$) in the development area.	Negligible for PTS (permanent effect with less than 0.001% of reference population likely to be affected). Negligible for TTS (temporary effect with less than 1% of reference population likely to be affected).
Harbour seal			0.018 harbour seal (0.00004% ref pop; 0.00037% SE England MU) based on density ($0.008/km^2$) in the development area.	

11.6.1.6.3 Impact Significance

420. 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), the impact significance for any permanent or temporary auditory injury (PTS or TTS) in harbour porpoise, grey seal and harbour seal from vessels has been assessed as a precautionary **minor adverse**; therefore, no further mitigation measures are proposed.

421. 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 possible behavioural response of harbour porpoise as a result of underwater noise from vessels has been assessed as **negligible**, (***Table 11.44***); therefore no further mitigation measure are proposed beyond those proposed in ***section 11.3.3***.

422. 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.

423. The confidence in the data used in this assessment is medium to high.

Table 11.44 Assessment of Impact Significance for Underwater Noise and Disturbance from Vessels on Marine Mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Permanent auditory injury (PTS) from cumulative SEL from vessels during construction, based on 24 hour exposure	Harbour porpoise	High	Negligible	Minor adverse	No further mitigation proposed	**Minor adverse**
	Grey seal	High	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	High	Negligible	Minor adverse		**Minor adverse**
Temporary auditory injury (TTS) / fleeing response from cumulative SEL from vessels during construction, based on 24 hour exposure	Harbour porpoise	Medium	Negligible	Minor adverse	No further mitigation proposed	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Possible behavioural response to underwater noise from vessels during construction	Harbour porpoise	Low	Negligible	Negligible	No mitigation required	**Negligible**

11.6.1.7 Impact 7: Barrier Effects as a Result of Underwater Noise

424. 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 rather than going through it. However, the East Anglia ONE North offshore development area is not located on any known migration routes for marine mammals. Seal telemetry studies (see ***Appendix 11.2***) and the relatively low seal at sea usage observed (Russell et al. 2017; ***Figure 11.2*** and ***11.3***) in and around the offshore development area (***section 11.5.2*** and ***11.5.3***) do not indicate any regular seal foraging routes through the site.

11.6.1.7.1 Sensitivity

425. Harbour porpoise, grey seal and harbour seal are assessed as having medium sensitivity to a barrier effect as a result of disturbance (***Table 11.27***).

11.6.1.7.2 Magnitude

426. 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.

11.6.1.7.2.1 Maximum Spatial Impact for Any Barrier Effects

427. The spatial worst-case is the maximum area over which potential disturbance could occur at any one time based on single foundation installation (2,124km^2).

428. As outlined in ***section 11.6.1.4.1.2***, the estimated maximum number of harbour porpoise that may be temporarily disturbed as a result of underwater noise from single piling is 0.4% of the reference population (***Table 11.35***). 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.

429. The estimated maximum number of grey seal that could potentially be disturbed as a result of underwater noise from single piling is 0.01% of the reference population (0.02% 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 11.35***).

430. The estimated maximum number of harbour seal that could potentially be disturbed as a result of underwater noise from single piling is 0.002% of the reference population (0.02% 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 11.35***).

11.6.1.7.2.2 Maximum Temporal Impact for Any Barrier Effects

431. The maximum total piling duration for wind turbines and platforms (including soft-start and ramp-up) would be 844.8 hours (35.2 days) (***Table 11.2***). The maximum duration of any ADD activation would be up to 52 hours (2.2 days). Therefore, the maximum duration for potential disturbance during piling is up to 37.4 days.

432. As outlined above, it is important to note that piling and therefore any potential barrier effects would not be constant during construction and there is expected to be significant periods when piling would not be ongoing. 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.

433. The magnitude for any potential barrier effect 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.

11.6.1.7.3 Impact Significance

434. Piling activity would only be for a very small proportion of the overall construction period, therefore any potential barrier effects from piling activity would only be temporary. Underwater noise from other activities (***section 11.6.1.5***) and vessels (***section 11.6.1.6***) would be within the potential disturbance range for piling, have a limited area of potential disturbance and negligible magnitude of effect, and would therefore not result in any potential barrier effects.

435. Taking into account the receptor sensitivity and the potential magnitude of the temporary impact, the impact significance for any potential barrier effect 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 11.45***).

436. 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 11.45 Assessment of Impact Significance for Any Barrier Effects from Underwater Noise

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	Negligible	Minor adverse	MMMP and SIP, if required.	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**

11.6.1.8 Impact 8: Vessel Interaction (Collision Risk) During Construction

437. During the offshore construction phase of the proposed East Anglia ONE North project there will be an increase in vessel traffic within the offshore development area and to and from the windfarm site. However, it is anticipated that vessels would follow an established shipping route to the relevant ports in order to minimise vessel traffic in the wider area.

11.6.1.8.1 Sensitivity

438. Marine mammals in the East Anglia ONE North offshore development area would be habituated to the presence of vessels (given the existing levels of marine traffic, see ***Chapter 14 Shipping and Navigation***) 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.

11.6.1.8.2 Magnitude

439. The approximate number of vessels on site at any one time during construction is estimated to be 74 vessels, with an average of approximately 124 trips per month (***Table 11.2***), resulting in a daily average of approximately 4.1 vessel movements.

440. As outlined in ***Chapter 14 Shipping and Navigation***, the baseline conditions indicate an already relatively high level of shipping activity in and around the offshore development area. Therefore, based on an average of 4.1 vessel movements per day, the increase in vessels during construction could be up to a 3.5% increase in the number of vessels during the summer period and 4.1% increase in the number of vessels during the winter periods, compared to current baseline vessel numbers.

441. 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.

442. 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).

443. Harbour porpoise 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 porpoise in the North Sea suggesting porpoise could exhibit avoidance behaviour which reduces the risk of strikes.

444. Of the 273 reported harbour porpoise strandings in 2015 (latest UK Cetacean Strandings Investigation Programme (CSIP) 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).

445. Although the risk of collision is likely to be low, as a precautionary worse-case scenario, the number of harbour porpoise, grey seal and harbour seal that could be at increased collision risk with vessels during construction has been assessed based on 5-10% of the number of animals that could be present in the East Anglia ONE North offshore development area potentially being at increased collision risk (***Table 11.46***).

446. This is a highly precautionary assumption, as it is unlikely that marine mammals present in the East Anglia ONE North offshore development area would be at increased collision risk with vessels during construction, considering the minimal number of vessel movements compared to the existing number vessel movements in the area, and that vessels within the wind farm and cable corridor would be stationary or very slow moving. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed as a result of the vessel noise (***section 11.6.1.6***), there should be no potential for increased collision risk with vessels in the offshore development area during piling.

Table 11.46 Estimated Number of Harbour Porpoise, Grey Seal and Harbour Seal that Could be Present in the East Anglia ONE North Offshore Development Area at Potential Increased Vessel Collision Risk

Potential Impact Area	Receptor	Estimated number at potential collision risk based on 5-10% increased risk (% of reference population)	Magnitude for permanent impact
East Anglia ONE North offshore development area (341km^2)	Harbour porpoise	10.3-20.7 harbour porpoise (0.003%-0.006% of the reference population) based on SCANS-III survey density (0.607/km^2). 9.88-19.8 harbour porpoise (0.003%-0.006% of the reference population) based on EA1N survey density (0.58/km^2).	Permanent impact with low magnitude (between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).
	Grey seal	0.5-1 grey seal (0.002%-0.005% ref pop; 0.006%-0.012% SE England MU) based on density (0.03/km^2) in the development area.	Permanent impact with low magnitude (between 0.001% and 0.01% of the reference population anticipated to be exposed to effect).
	Harbour seal	0.14-0.27 harbour seal (0.0003%-0.0006% ref pop; 0.003%-0.005% SE England MU) based on density (0.008/km^2) in the development area.	Permanent impact with negligible magnitude (less than 0.001% of the reference population anticipated to be exposed to effect).

11.6.1.8.3 Impact Significance

447. 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 and grey seal and **negligible** for harbour seal (***Table 11.47***).

448. Vessel movements, where possible, will be along set 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.

449. The confidence in the data used in this assessment is medium.

Table 11.47 Assessment of Impact Significance for Increased Collision Risk from Vessels During Construction

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Increased collision risk from vessels during construction for total offshore project area	Harbour porpoise	Low	Low	Minor adverse	No further mitigation proposed other than good practice.	**Minor adverse**
	Grey seal	Low	Low	Minor adverse		
	Harbour seal	Low	Negligible	Negligible		**Negligible**

11.6.1.9 Impact 9: Changes to Prey Resource

450. 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).

11.6.1.9.1 Sensitivity

451. 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 11.5.1.2***, 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.

452. Grey and harbour seal feed on a variety of prey species. Both species are considered to be opportunistic feeders that are able to forage in other areas and have relatively large foraging ranges (see ***sections 11.5.2.3***, ***11.5.3.3*** and ***Appendix 11.2***). Grey seal and harbour seal are therefore considered to have low sensitivity to changes in prey resources.

11.6.1.9.2 Magnitude

453. Potential impacts on marine mammal prey species have been assessed in ***Chapter 10 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. All the potential impacts are assessed as being not significant (minor adverse at worst).

454. As outlined in ***Chapter 10 Fish and Shellfish Ecology***, the maximum (worst-case scenario) potential area of physical disturbance and/or temporary loss of habitat to fish during construction (up to $10.6km^2$) is likely to be a very small proportion (approximately 3%) of the offshore development area. The assessment determined that with negligible to low magnitude of impact, the impact significance on fish species, including sandeel and herring, would be minor adverse.

455. 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. Therefore, the assessment determined that the impact significance on fish species, including sandeel and herring, would be minor adverse (***Chapter 10 Fish and Shellfish Ecology***).

456. 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 11.4***), 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).

457. The underwater noise modelling results (***Chapter 10 Fish and Shellfish Ecology*** and ***Appendix 11.4***) indicate that fish species in which the swim bladder is both involved and not involved in hearing are the most sensitive to the impact of piling noise with impact ranges of up to 500m for mortality and potential mortal injury for SPL_{peak} (for monopile with full hammer energy of 4,000kJ) and up to 6.2km for recoverable injury, based on maximum potential ranges for cumulative exposure (SEL_{cum} for pin pile with full hammer energy) assuming a fleeing receptor, travelling at a speed of 1.5m/s (Hirata 1999).

458. Under a stationary receptor scenario, an impact range of up to 15km has been modelled for recoverable injury, based on the maximum potential ranges for cumulative exposure (SEL_{cum} for monopile with full hammer energy). It should be noted that using a stationary receptor is considered to be over precautionary as most fish species are likely to move away from a sound that is loud enough to cause harm (Dahl et al. 2015; Popper et al. 2014), some may seek protection in

the sediment and others may dive deeper in the water column. In addition, the flee speed used of 1.5m/s is relatively slow in relation to the data shown in Hirata (1999) and is therefore considered to be conservative. There is further evidence that those fish species that do not flee are likely to be benthic fish species or to not have a swim bladder, which are the least sensitive species. More information is included within ***Appendix 11.4***.

459. 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 (up to 39km for a stationary receptor) could occur, the assessment in ***Chapter 10 Fish and Shellfish Ecology***, determined the potential impact to be negligible to minor adverse (not significant) for all fish species, including for the key marine mammal prey species of sandeel, herring, whiting, sprat, cod and sole.

460. 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 East Anglia ONE North offshore development area (341km^2). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire offshore development area during construction. It is more likely that effects would be restricted to an area around the working sites.

461. In addition, there would be no additional displacement of marine mammals as a result of any changes in prey resources during construction, as they would already be potentially disturbed from the offshore development area 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.

462. Based on the very precautionary approach that any changes in prey resource could occur across the entire offshore development area, up to 207 harbour porpoise (or 0.06% of the North Sea MU reference population, using the SCANS-III density of 0.607 per km^2 as a worst-case), 10 grey seal (0.05% of reference population; 0.12% of the grey seal South-east England MU) and up to 3 harbour seal (0.006% of reference population; 0.06% of the harbour seal South-east MU) could be temporarily displaced.

463. The magnitude of effect is negligible for harbour porpoise, grey seal and harbour seal, for 100% displacement from the East Anglia ONE North offshore development area, with less than 1% of the reference population being potentially temporarily affected by any changes to prey resources.

11.6.1.9.3 Impact Significance

464. 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 11.48***); therefore no further mitigation measures are proposed beyond those embedded measures presented in ***section 11.3.3***.

465. The confidence in the data used in this assessment is medium.

Table 11.48 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 adverse	No further mitigation required, other than proposed mitigation in ***Chapter 10 Fish and Shellfish Ecology***.	**Negligible to Minor adverse**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		

11.6.2 Potential Impacts During Operation

466. Potential impacts during operation will mostly result from the presence of routine vessels within the East Anglia ONE North windfarm site, underwater noise and the impacts on prey species during maintenance activities. These will be similar to impacts assessed for construction, but lower in magnitude.

467. Note that effects from EMF and physical barrier effects were not considered within the Method Statement as these were scoped out of consideration for recent projects as there is no evidence of any potential impact (see ETG 2 Follow-up Note (SPR 2018)).

468. The potential impacts during operation and maintenance assessed for marine mammals are:

1) Behavioural impacts resulting from the underwater noise associated with operational wind turbines;
2) Behavioural impacts resulting from the underwater noise associated with maintenance activities, such as any additional rock dumping and cable re-burial;
3) Behavioural impacts resulting from the underwater noise and disturbance from vessels;

4) Vessel interaction (collision risk); and
5) Changes to prey resource.

11.6.2.1 Impact 1: Potential Impacts Resulting from the Underwater Noise Associated with Operational Wind Turbines

11.6.2.1.1 Sensitivity

469. Currently available data indicates that there is no lasting disturbance or exclusion of harbour porpoise or seals around windfarm 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).

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

471. Monitoring studies at Nysted and Rødsand have also indicated that operational activities have had no impact on regional seal populations (Teilmann et al. 2006; McConnell et al. 2012). Tagged harbour seals have been recorded within two operational windfarm 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).

472. 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 wind turbines. The sensitivity of marine mammals to permanent auditory injury (PTS) is considered to be high, and medium for temporary auditory effect (TTS) / fleeing response.

11.6.2.1.2 Magnitude

473. Underwater noise modelling was undertaken to assess the potential impact ranges of operational wind turbines on marine mammals. The underwater noise propagation modelling was undertaken using a simple modelling approach for

underwater noise associated with operational wind turbines, using measured sound source data scaled to relevant parameters for the East Anglia ONE North windfarm site (see ***Appendix 11.4*** for further information).

474. To predict the operational noise levels at the East Anglia ONE North windfarm site, the noise levels of existing operational wind turbines were used to predict the noise levels for the East Anglia ONE North wind turbines based on the size of the turbines (see ***Appendix 11.4*** for more information). The sound sources for operational wind turbines modelled were 164.1dB re 1µP (RMS) @1m for 300m turbines.

475. The results of the underwater noise modelling indicate that at the source levels predicted for operational underwater noise, any marine mammal would have to remain in close proximity (i.e. less than 100m) of the wind turbine for 24 hours to be exposed to levels of sound that are sufficient to induce PTS or TTS as a result of cumulative exposure as per the NMFS (2018) threshold criteria (***Table 11.49***).

Table 11.49 Maximum Predicted Impact Ranges (and Areas) for Auditory Injury (PTS) and for Possible Behavioural Response from Operational Turbine Noise

Potential Impact		The modelled impact ranges (km) (and areas* (km^2) for operational turbines	
	Receptor	Threshold and criteria	Operational Wind Turbine (300 turbine)
Permanent auditory injury (PTS) from cumulative SEL from operational wind turbines, based on 24 hour exposure	Harbour porpoise	NMFS (2018) 173 dB re 1 µPa²s	<0.1km (0.031km²)
	Grey and Harbour seal	NMFS (2018) 201 dB re 1 µPa²s	<0.1km (0.031km²)
Temporary auditory injury (TTS) from cumulative SEL from operational wind turbines, based on 24 hour exposure	Harbour porpoise	NMFS (2018) 153 dB re 1 µPa²s	<0.1km (0.031km²)
	Grey and Harbour seal	NMFS (2018) 181 dB re 1 µPa²s	<0.1km (0.031km²)
Possible behavioural response to underwater noise from operational wind turbines	Harbour porpoise	Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa	0.08km (0.02km²)

**Maximum area based on area of circle with maximum impact range for radius as worst-case scenario*

476. The number of harbour porpoise, grey seal and harbour seal that could be disturbed as a result of underwater noise from operational wind turbines has been

assessed based on the number of animals that could be present in each of the modelled impact ranges (***Table 11.50***).

Table 11.50 Maximum Number of Individuals (and % of Reference Population) that Could Be Impacted as a Result of Underwater Noise Associated with Operational Turbines

Potential Impact (area km²)	Receptor	Criteria and Threshold	Estimated number in impact area (% of reference population)	Magnitude
300m operational wind turbines x 53	Harbour porpoise	PTS from cumulative SEL NMFS (2018) 173 dB re 1 µPa²s And TTS from cumulative SEL NMFS (2018) 153 dB re 1 µPa²s (1.3km²)	0.79 harbour porpoise (0.00023% of the reference population) based on SCANS-III survey density (0.607/km²). 0.75 harbour porpoise (0.00022% of the reference population) based on EA1N survey density (0.58/km²).	Negligible for PTS (permanent effect with less than 0.001% of reference population likely to be affected). Negligible for TTS / fleeing response (temporary long-term effect with less than 0.01% of reference population likely to be affected).
		Possible behavioural response Lucke et al. (2009) Unweighted SEL 145 dB re 1 µPa (0.84km²)	0.51 harbour porpoise (0.00015% of the reference population) based on SCANS-III survey density (0.607/km²). 0.49 harbour porpoise (0.00014% of the reference population) based on EA1N survey density (0.58/km²).	Temporary long-term effect with negligible magnitude (less than 0.01% of reference population likely to be affected).
	Grey seal	PTS from cumulative SEL NMFS (2018) 201 dB re 1 µPa²s And TTS from cumulative SEL NMFS (2018) 181 dB re 1 µPa²s (1.3km²)	0.0013 grey seal (0.000006% ref pop; 0.00002% SE England MU) based on density (0.001/km²) in the EA1N windfarm area.	Negligible for PTS (permanent effect with less than 0.001% of reference population likely to be affected). Negligible for TTS / fleeing response (temporary long-term effect with less than 0.01% of reference population likely to be affected).
	Harbour seal		0.00065 harbour seal (<0.000001% ref pop; 0.00001% SE England MU) based on density (0.0005/km²) in the EA1N windfarm area.	

477. The magnitude of the potential impact of auditory injury (PTS or TTS) and any disturbance / fleeing response as a result of operational wind turbine noise is negligible for harbour porpoise, grey seal and harbour seal, with less than 0.001% of the reference population likely to be affected for permanent impact (PTS) and less than 1% of the population temporarily disturbed, based on long-term temporary disturbance (***Table 11.50***).

11.6.2.1.3 Impact Significance

478. The impact significance for any PTS, TTS / fleeing response or possible behavioural response, taking into account the receptor sensitivity of high, medium and low respectively, and the potential magnitude of effects as a result of operational wind turbines has been assessed as a very precautionary **minor adverse** to **negligible (not significant)** for harbour porpoise, grey seal and harbour seal (***Table 11.51***).

479. The confidence in the data used in this assessment is medium.

Table 11.51 Assessment of Impact Significance of Underwater Noise from Operational Wind Turbines on Marine Mammals

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Permanent auditory injury (PTS) from cumulative SEL	Harbour porpoise	High	Negligible	Minor adverse	No mitigation required	**Minor adverse**
	Grey seal	High	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	High	Negligible	Minor adverse		**Minor adverse**
Temporary auditory injury (TTS) / fleeing response from cumulative SEL	Harbour porpoise	Medium	Negligible	Minor adverse	No mitigation required	**Minor adverse**
	Grey and harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Possible behavioural response	Harbour porpoise	Low	Negligible	Negligible	No mitigation required	**Negligible**

11.6.2.2 Impact 2: Behavioural Impacts Resulting from the Underwater Noise Associated with Maintenance Activities, such as any Additional Rock Dumping and Cable Re-burial

480. All offshore infrastructure including wind turbines, foundations, cables and offshore electrical platforms would be monitored and maintained during the operational period.

11.6.2.2.1 Sensitivity

481. As outlined in ***section 11.6.1.5.1***, the sensitivity of marine mammals to disturbance as a result of underwater noise during maintenance activities, such as cable installation, is considered to be medium in this assessment as a precautionary approach.

11.6.2.2.2 Magnitude

482. 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.

483. As outlined in ***section 11.6.1.5.2***, the potential for PTS is only likely in very close proximity to cable laying or rock dumping activities and only then if the individual remains within close proximity for 24 hours. There is also the potential for noise from maintenance activities to cause disturbance.

484. 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 activity is actually taking place.

485. The underwater noise from maintenance activities is considered to be the same or less than underwater noise from other construction activities (including rock dumping, trenching and cable laying) and therefore the impact of maintenance activities will be the same or less than for other construction activities (***Table 11.39*** and ***Table 11.40***).

486. The magnitude of effect in all species is assessed to be negligible based on the maximum number of animals within the modelled impact areas for other construction activities (***Table 11.40***).

11.6.2.2.3 Impact Significance

487. The impact significance for any disturbance of harbour porpoise, grey seal and harbour seal during maintenance activities has been assessed as **negligible** to **minor adverse (not significant)** (***Table 11.41***); therefore, no further mitigation measures are proposed beyond those presented in ***section 11.3.3***.

488. The confidence in the data used in this assessment is medium and the level of precaution is high.

11.6.2.3 Impact 3: Underwater Noise and Disturbance from Maintenance Vessels

11.6.2.3.1 Sensitivity

489. As outlined in ***section 11.6.1.6.1***, the sensitivity of harbour porpoise, grey seal and harbour seal is low to vessel noise.

11.6.2.3.2 Magnitude

490. The requirements for any potential maintenance work are currently unknown, however, the work required, and the impacts associated with underwater noise and disturbance from vessels during operation and maintenance would be less than those during construction. It is estimated that there could be up to 647 vessel round trips per year (1-2 vessels per day) during operation and maintenance (***Table 11.2***).

491. As outlined in ***section 11.6.1.6.2***, the potential for PTS is only likely in very close proximity to vessels if the individual remains in close proximity for 24 hours. There is also the potential for disturbance impacts from vessel noise.

492. Taking into account the existing vessel movements in and around the East Anglia ONE North offshore development area and the potential 1-2 vessel movements per day during operation and maintenance, the number of vessels would not exceed the Heinänen and Skov (2015) threshold level of approximately 80 vessels per day per day within an area of 5km^2 (approximately 16 vessels per km^2). Therefore, there is no potential for the significant disturbance to harbour porpoise as a result of the increased number of vessels during operation and maintenance.

493. The noise modelling (***Table 11.42***) indicates that the potential area of disturbance around each vessel could be up to 0.071km^2 for harbour porpoise and less than 0.031km^2 for grey and harbour seal. Therefore, for the 1-2 vessels per day during operation and maintenance, the number of harbour porpoise that could potentially be disturbed is 0.09 (or 0.00002% of NS MU based on the SCANS-III density as a worst-case), with up to 0.002 grey seal (0.00001% of reference population; 0.00002% of SE MU) and up to 0.0005 harbour seal (0.000001% of reference population; 0.00001% of SE MU). Therefore, the magnitude of effect is negligible, with less than 1% of the reference populations temporarily disturbed.

11.6.2.3.3 Impact significance

494. 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 11.51***); therefore no

further mitigation measure are proposed beyond those presented in ***section 11.3.3***.

495. The confidence in the data used in this assessment is medium to high.

Table 11.52 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 porpoise	Low	Negligible	Negligible	No mitigation required or proposed	**Negligible**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

11.6.2.4 Impact 4: Vessel Interaction (Collision Risk) during Operation and Maintenance

11.6.2.4.1 Sensitivity

496. As outlined in ***section 11.6.1.8.1***, marine mammals in the East Anglia ONE North offshore development 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.

11.6.2.4.2 Magnitude

497. As outlined above, it estimated that there could be 1 - 2 vessel trips per day during operation and maintenance (***Table 11.2***). Taking into account the existing vessel movements in and around the East Anglia ONE North offshore development area and the potential disturbance from vessels, the potential increased collision risk as a result of vessels during operation and maintenance is considered to be negligible.

11.6.2.4.3 Impact Significance

498. The impact significance for any potential increase in collision risk with vessels during operation and maintenance has been assessed as **negligible** for harbour porpoise, grey seal and harbour seal (***Table 11.53***). No further mitigation measures are proposed.

499. The confidence in the data used in this assessment is medium to high.

Table 11.53 Assessment of Impact Significance for Increased Collision Risk from Vessels During Operation and Maintenance Activities

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Increased collision risk from vessels during operation and maintenance activities	Harbour porpoise	Low	Negligible	Negligible	No mitigation required or proposed	**Negligible**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

11.6.2.5 Impact 5: Changes to Prey Resources during Operation and Maintenance

11.6.2.5.1 Sensitivity

500. As outlined in ***section 11.6.1.9.1***, 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.

11.6.2.5.2 Magnitude

501. Potential impacts on marine mammal prey species have been assessed in ***Chapter 10 Fish and Shellfish Ecology*** using the appropriate realistic worst-case scenarios for these receptors during operation and maintenance.

502. Potential impacts on fish species during operation and maintenance could 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 10 Fish and Shellfish Ecology***).

503. The introduction of hard substrate, such as wind turbine towers, foundations and associated scour protection and cable protection would increase habitat heterogeneity through the introduction of hard structures in an area predominantly characterised by sediment habitats. As outlined in ***Chapter 10 Fish and Shellfish Ecology***, the worst-case total area of habitat loss has been estimated to be 1.9km^2; this would account for a very small proportion of (approximately 0.6%) of the offshore development area. Therefore, with the low to negligible 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 10 Fish and Shellfish Ecology***).

504. Underwater noise modelling for disturbance of fish species indicates that the maximum potential impact range for 300m wind turbines is less than 50m around each wind turbine, therefore, using this impact range as the worst-case, the

maximum potential area of disturbance would be 0.53km^2 for all 67 300m wind turbines (using the modelled impact range for the 300m wind turbines as a worst-case). Therefore, with the low magnitude of effect, the impact was considered to be of negligible to minor adverse significance for fish species (***Chapter 10 Fish and Shellfish Ecology***).

505. As outlined in ***Chapter 10 Fish and Shellfish Ecology***, the areas potentially affected by EMFs generated by the worst-case scenario offshore cables are expected to be restricted to the immediate vicinity of the cables (i.e. within metres). This would be 200km of 75kV Alternating Current (AC) inter-array cables, 75km of 400kV platform link cables and 152km of 600kV High Voltage Alternating Current (HVAC) offshore export cables. EMFs are expected to attenuate rapidly in both horizontal and vertical plains with distance from the source. As a worst-case, the estimated maximum area of disturbance is approximately 8.54km^2, based on a worst-case of 10m each side of 427km maximum cable length. The magnitude of the effect on fish species is therefore considered to be low and the impact of EMFs of negligible to minor adverse significance (***Chapter 10 Fish and Shellfish Ecology***).

506. Based on the worst-case scenario for the total area that prey species could be displaced (loss of habitat, hard substrates including scour protection, noise from operational wind turbines and EMF from cables; up to 10.97km^2), approximately seven harbour porpoise (or 0.002% of the North Sea MU reference population based on the SCANS-III density as a worst-case), 0.3 grey seal (0.002% of reference population; 0.004% of the grey seal South-east England MU) and up to 0.1 harbour seal (0.0002% of reference population; 0.002% of the harbour seal South-east England MU) could be displaced.

507. The magnitude of effect is **negligible** for harbour porpoise, grey seal and harbour seal, with less than 0.01% of the reference population being potentially long-term temporarily affected by any changes to prey resources.

11.6.2.5.3 Impact Significance

508. The impact significance for any changes in prey resource has been assessed as **negligible** to **minor adverse** for harbour porpoise and **negligible** for grey seal and harbour seal (***Table 11.54***); therefore, no further mitigation measures are proposed.

509. The confidence in the data used in this assessment is medium.

Table 11.54 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 adverse	No mitigation required or proposed	**Negligible to Minor adverse**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

11.6.3 Potential Impacts During Decommissioning

510. Possible effects on marine mammals associated with the decommissioning have not been assessed in detail, as a detailed 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. The impact assessment for effects associated with decommissioning assumes that impacts are within those assessed for construction and operation and maintenance phases. A detailed decommissioning plan will be provided to the regulator prior to decommissioning that will give details of the techniques to be employed and any relevant mitigation measures required.

511. The potential impacts during decommissioning assessed for marine mammals are:

1) Physical and auditory injury resulting from the noise associated with foundation removal (e.g. cutting);
2) Behavioural impacts resulting from the noise associated with foundation removal (e.g. cutting);
3) Underwater noise and disturbance from vessels;
4) Barrier effects as a result of underwater noise associated with activities above;
5) Vessel interaction (collision risk); and
6) Changes to prey resource.

11.6.3.1 Impact 1: Physical and Auditory Injury Resulting from the Noise Associated with Foundation Removal

512. Decommissioning would most likely involve the removal of the accessible installed components comprising: all of the wind turbine components; part of the foundations (those above 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.

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

514. For this assessment, it is assumed that the potential impacts from underwater noise during decommissioning would be less than those assessed for piling (***section 11.6.1.3***).

11.6.3.2 Impact 2: Behavioural Impacts Resulting from the Noise Associated with Foundation Removal

515. For this assessment, it is assumed that the potential impacts from underwater noise during decommissioning would be less than those assessed for piling (***section 0***) and comparable to those assessed for other construction activities (***section11.6.1.5***).

11.6.3.3 Impact 3: Underwater noise and disturbance from vessels

516. For this assessment, it is assumed that the potential impacts would be the same as for construction (see ***section 11.6.1.6***).

11.6.3.4 Impact 4: Vessel interaction (collision risk)

517. For this assessment, it is assumed that the potential impacts would be the same or less than for construction (see ***section 11.6.1.8***).

11.6.3.5 Impact 5: Barrier Effects as a Result of Underwater Noise

518. 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 11.6.1.7***).

11.6.3.6 Impact 6: Changes to Prey Resources

519. For this assessment, it is assumed that the potential impacts would be the same or less than for construction (see ***section 11.6.1.9***).

11.7 Cumulative Impacts

520. As outlined in ***section 11.4.5***, 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 the proposed East Anglia ONE North project.

521. The plans and projects screened in to the CIA are located in the relevant marine mammal reference population areas for harbour porpoise, grey seal and harbour

seal (as defined in ***Table 11.16***). Full information on the CIA screening methods and projects screened in to the CIA are provided in ***Appendix 11.3***.

11.7.1 Plans and Projects

522. 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 (see ***Appendix 11.3***). This approach allows for the different levels of 'uncertainty' to be taken into account in the CIA, as well as the quality of the data available (as outlined in ***section 11.4.5***).

11.7.1.1 Tier 1 Projects

523. Tier 1 projects are relevant operational projects and therefore there is no potential for any overlap in the construction of these projects with the construction within the East Anglia ONE North offshore development area.

- Tier 1 offshore windfarms have the potential for cumulative operational, maintenance and decommissioning impacts and were screened into the CIA.
- All other tier 1 projects were considered part of the baseline and not included in the CIA (see ***Appendix 11.3***).

11.7.1.2 Tier 2 Projects

524. Tier 2 projects are marine infrastructure projects currently under construction and which are due to be commissioned prior to the construction of the proposed East Anglia ONE North project, therefore there is no potential for any overlap in the construction and piling of these projects with the construction and piling within the East Anglia ONE North offshore development area.

- Tier 2 offshore windfarms could have possible cumulative operational, maintenance and decommissioning impacts.
- All other tier 2 projects were screened out of the CIA (see ***Appendix 11.3***).

11.7.1.3 Tier 3 Projects

525. 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 offshore windfarm 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.

526. However, there is still significant uncertainty associated with these projects, for example, in terms of the scale of the final development that will be constructed, construction programme dates and the likely final impacts. In particular, offshore

windfarm 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 prior to construction.

- Tier 3 offshore windfarms could have possible cumulative construction, operational, maintenance and decommissioning impacts.
- All other Tier 3 projects were screened out of the CIA (see ***Appendix 11.3***).

11.7.1.4 Tier 4 Projects

527. 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.

- Tier 4 offshore windfarms could have possible cumulative construction, operational, maintenance and decommissioning impacts.
- All other tier 4 plans and projects were screened out of the CIA (see ***Appendix 11.3***).

11.7.1.5 Tier 5 Projects

528. 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). For tier 5 projects there is a lot of uncertainty and not enough information to allow a robust assessment. However, as a very precautionary approach, the tier 5 UK offshore windfarm projects that we are currently aware of have been included in the CIA.

- Tier 5 offshore windfarms could have possible cumulative construction, operational, maintenance and decommissioning impacts.
- All other tier 5 plans were screened out of the CIA (see ***Appendix 11.3***).

11.7.2 Types of Cumulative Impacts and Approach to Assessment

529. Types of impact considered in the CIA are summarised in ***Table 11.55***. 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 temporarily overlap with the proposed East Anglia ONE North project. Each type of potential cumulative impact has been assessed, where relevant, for harbour porpoise, grey seal and harbour seal.

11.7.2.1 Underwater Noise

530. The potential sources of underwater noise during each stage of a plan or project are summarised in ***Table 11.55***.

531. Auditory injury (PTS) could occur as a result of pile driving during offshore windfarm 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 windfarms, 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.

532. The CIA assessment determines the potential for disturbance to marine mammals from underwater noise sources during the offshore construction, operation, maintenance and decommissioning of the proposed East Anglia ONE North project.

533. The approach to the assessment for cumulative disturbance from underwater noise has been based on the approach for the assessment of disturbance alone in ***section 11.6.1.4.1***, and follows the current advice from the SNCBs on the assessment of impacts on the SNS harbour porpoise SAC as outlined in ***section 11.5.4.1***. The CIA has therefore 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.

534. 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.

535. 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. Therefore, the higher frequencies typically used 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 (2017e) do not, therefore, advise that 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.

536. The draft RoC HRA for the Southern North Sea SAC (BEIS 2018) undertook underwater noise modelling to determine the potential impact ranges of geophysical surveys for harbour porpoise. The assessment used the maximum source levels that could be expected from geophysical equipment: sub-bottom profilers, with a maximum source noise level of 267 dB re 1 µPa-m. The noise modelling indicates that the onset of PTS in harbour porpoise could occur within a maximum range of 23m (an area of 0.0017km^2) from the source location (BEIS, 2018) for the PTS cumulative threshold of 155dB SEL weighted (NMFS 2018). For possible behavioural disturbance of harbour porpoise, based on a threshold of 140 dB re 1 µPa SPL unweighted the maximum range was 3.77km (44.65km^2) (BEIS 2018).

537. The potential disturbance from offshore windfarms during non-piling construction activities including vessels, seabed preparation, rock dumping and cable installation, has been based on the area of the offshore windfarm sites, this is a precautionary approach, as it is highly unlikely that non-piling construction activities would result in disturbance from entire offshore windfarm sites or offshore cable routes. Any disturbance is likely to be limited to the area in and around where the activity is taking place.

538. The potential disturbance from operational offshore windfarms and maintenance activities, including vessels, any rock dumping or cable re-burial, has also been based on the area of the offshore windfarm sites, this is again a precautionary approach, as it is highly unlikely that operational offshore windfarms and maintenance activities, including vessel operations, would result in disturbance from entire offshore windfarm sites or offshore cable routes. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place.

539. 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.

540. 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 EIAs, based on different noise models, thresholds and criteria, as well as different approaches to density estimates.

11.7.2.2 Changes in Prey Availability

541. 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 cumulative 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 (as indicated by the noise modelling in ***section 11.6.1.3*** and ***11.6.1.9***), therefore any changes to prey availability would not affect marine mammals as they would already be disturbed from the same area.

11.7.2.3 Increased Collision Risk

542. As outlined in ***section 11.6.1.8***, it is difficult to quantify the increased collision risk to marine mammals.

543. The potential increased collision risk with vessels during the construction and decommissioning of offshore windfarms has used a similar precautionary approach as outlined in ***section 11.6.1.8***. 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 East Anglia ONE North windfarm 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 windfarm sites taking into account a possible 5% increase collision risk. This is very precautionary, as it is highly unlikely that all marine mammals present in the windfarm areas would be at increased collision risk with vessels.

544. 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 5% increased collision risk. 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 5% increased collision risk.

Table 11.55 Impacts Considered Within the CIA

Impact	Sources of impact and stages of projects	Potential cumulative effects
Impact 1 Underwater noise impacts during construction from offshore windfarm piling	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 East Anglia ONE North, resulting in maximum potential for underwater piling noise to interact cumulatively in the regional marine mammal reference population boundaries. 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 the proposed East Anglia ONE North project, but which occur immediately prior to or after and therefore increase the overall duration of sequential piling within the marine mammal reference population boundaries. Maximum spatial adverse scenario considers the maximum area of which marine mammal could be disturbed as a result of offshore piling.
Impact 2 Underwater noise impacts from all other noise sources	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 the proposed East Anglia ONE North project, 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	Cumulative increase in noise for non-piling activities 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:

Impact	Sources of impact and stages of projects	Potential cumulative effects
	noise; dredging noise; wind turbine or other mechanical operational noise; foundation / cable removal; UXO clearance and explosives: Construction; Operation and maintenance; and Decommissioning	• Projects with overlapping construction phases with the proposed East Anglia ONE North project, 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 3 Changes to 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 the proposed East Anglia ONE North project, 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.

Impact	Sources of impact and stages of projects	Potential cumulative effects
Impact 4 Vessel and other interactions	Vessels: 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 collision risk to marine mammals. Included in the CIA: • Projects with overlapping construction phases with the proposed East Anglia ONE North project, 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.

11.7.3 Considerations for CIA

545. 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. As outlined in the tier approach, there is more information and certainty for lower tiers, compared to higher tiers.

546. 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 leads 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.

547. 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 included. It should therefore be noted that building precaution on precaution can lead to unrealistic worst-case scenarios within the assessment.

548. Therefore, the assessment is based on the most realistic worst-case scenario to reduce any uncertainty and avoid presentation of highly unrealistic worst-case scenarios, while still providing a conservative assessment. Careful consideration has been given to determine the most realistic worst-case scenario for the cumulative impact assessment.

549. 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). The Applicant 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 work to reduce potential impacts where appropriate.

550. As outlined in ***section 11.6.1.4.1.2***, the DEPONS model indicated the North Sea harbour porpoise population was not affected by the construction of 65

windfarms, as required to meet the EU renewable energy target (Nabe-Nielsen et al. 2018). However, windfarm construction schedules and the length of the breaks between individual piling events influenced the population effects of noise. In addition, when areas in the western North Sea were continuously exposed to noise for several years, the effect of noise was larger and more persistent than when windfarms were constructed in random order. Similarly, when windfarm construction involved near continuous pile driving, the population effects were larger than when local densities had more time to recover between consecutive pilings (Nabe-Nielsen et al. 2018). This therefore demonstrates how the modelling framework can be used for spatial planning to help mitigate population effects of disturbances.

551. For the proposed East Anglia One North project, the cumulative impact assessment has been based on East Anglia ONE North construction period as a worst-case scenario. In that the proposed East Anglia ONE North project will have the potential for increased cumulative impacts during this period compared to during the operation, maintenance and decommissioning phases.

11.7.4 Impact 1: Underwater Noise Impacts During Construction from Offshore Windfarm Piling

552. The greatest noise source is likely to result from pile driving during the construction of offshore windfarms. This stage of the cumulative assessment of underwater noise considers the potential disturbance of marine mammals during piling for the proposed East Anglia ONE North project with piling at other offshore windfarm projects screened into the CIA, where there is the potential for piling to be at the same time.

553. The assessment has been undertaken based on the most realistic worst-case scenario of the offshore windfarms that could be piling at the same time as the proposed East Anglia ONE North project. This scenario is based on a precautionary approach using the maximum duration of piling periods.

554. The UK tier 3, 4 and 5 offshore windfarms and European tier 3 offshore windfarms included in the most realistic worst-case scenario to assess the potential for cumulative disturbance of marine mammals during offshore windfarm piling, based on the periods of piling are outlined in ***Table 11.56***.

555. The realistic 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 more than 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 the Thanet Extension, Norfolk Vanguard and Norfolk Boreas, or between the East Anglia THREE, and the proposed East Anglia ONE

North and East Anglia TWO projects, and that only two of the four Dogger Bank projects could be piling at the same time. It has however been assessed that these projects could have overlapping construction windows, and therefore all offshore wind farm projects with overlapping offshore construction windows with the East Anglia ONE North project have been included for the assessment of other construction activities, unless they have previously been included within the assessment for cumulative piling with East Anglia ONE North (i.e. projects that have overlapping construction windows with the East Anglia ONE North Project, but do not have overlapping piling periods, have been included in the other construction activities assessment).

556. The CIA has been based on single piling within the East Anglia ONE North windfarm site, with single or concurrent piling in the other offshore windfarms identified to take place at the same time as piling at the proposed East Anglia ONE North project.

557. For the CIA, the potential piling period for the proposed East Anglia ONE North project has been based on the widest likely range of offshore construction dates between 2026 and 2028, as a very precautionary approach, and to allow for any delays to the proposed schedule.

558. At East Anglia ONE North, the maximum total piling duration for wind turbines and offshore platforms (including soft-start and ramp-up) would be 845 hours (35.2 days) (***Table 11.2***). The maximum active piling duration based on the worst-case scenario would be approximately 7.7% of the 27 month construction period.

559. These figures are typical of offshore windfarms 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 potential of concurrent piling occurring between offshore windfarms is also affected by other factors including seasonality, vessel market conditions and by weather in the North Sea.

Table 11.56 Offshore Windfarms 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 East Anglia ONE North. 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 EA1N (km)	Distance from EA1N cable corridor (km)	Size (MW)	Maximum number of wind turbines	Date of consent (7yr construction window)	Dates of offshore construction / piling[1]	Realistic worst-case scenario of piling occurring at the same time as EA1N
East Anglia ONE North	0	0	Up to 800	Up to 67	2020 (2020-2027)	2026-2028	Yes
Tier 3: consented							
Blyth Demonstration site (3A & 4)	103	379	58.4	10	2013 (2013-2020)	Unknown	No
Creyke Beck A, UK	249	257	1,200	200	Feb-15 (2015-2022)	2021-2027	No[2]
Creyke Beck B, UK	272	280	1,200	200	Feb-15 (2015-2022)	2021-2028	Yes[2]
East Anglia THREE, UK	17	35	1,200	172	Aug-17 (2017-2024)	Piling: 2020 – 2022	No
Hornsea Project Two, UK	163	167	1,386	165	Aug-16 (2016-2023)	2020-2022	No
Inch Cape, UK	529	527	784	110	2014 & 2017 (2017-2024)	2021-2022	No
Moray Firth East, UK	707	706	950	100	2014 (2014-2021)	2019-2022	No

Name and country of project	Distance from EA1N (km)	Distance from EA1N cable corridor (km)	Size (MW)	Maximum number of wind turbines	Date of consent (7yr construction window)	Dates of offshore construction / piling[1]	Realistic worst-case scenario of piling occurring at the same time as EA1N
Neart na Gaoithe, UK	511	507	448	75	2014 & 2017 (2017-2024)	2021	No
Sophia (formerly Teesside B), UK	268	276	1,200	200	Aug-15 (2015-2022)	2020-2028	Yes[2]
Teesside A, UK	282	290	1,200	200	Aug-15 (2015-2022)	2021-2028	No[2]
Triton Knoll Phase 1-3, UK	142.8	135	1,200	288	2013 (2013-2020)	2019-2022	No
Borkum Riffgrund West II, Germany	296	327	240	16-18	2017 (2017-2024)	Unknown	No
Borssele I and II, Netherlands	69	79	752	94	May-16 (2016-2023)	2019	No
Borssele III and IV, Netherlands	74	75	731.5	77	May-16 (2016-2023)	2020	No
Borssele Site V - Leeghwater - Innovation Plot, Netherlands	74	85	20	2	May-16 (2016-2023)	2020	No

Name and country of project	Distance from EA1N (km)	Distance from EA1N cable corridor (km)	Size (MW)	Maximum number of wind turbines	Date of consent (7yr construction window)	Dates of offshore construction / piling[1]	Realistic worst-case scenario of piling occurring at the same time as EA1N
Eoliennes du Calvados	367	341	450	75	2016 (2016-2023)	Unknown	No
Gode Wind 03, Germany	347	368	110	7-8	2016 (2016-2023)	2020	No
Gode Wind 04, Germany	347	369	450	75	2009 (2009-2016)	2023	No
Hollandse Kust Zuid Holland I and II - Chinook	131	110	684-760	58-126	2018 (2018-2025)	2023	No
Kaskasi, Germany	404	425	235	34	2018 (2018-2025)	2018-2022	No
Mermaid, Belgium	68	74	235	28	2015 (2015-2022)	2017-2019	No
Northwester 2, Belgium	44	77	224	22-38	2015 (2015-2022)	Unknown	No
Parc éolien en mer de Dieppe – Le Treport, France	256	224	496	62	2019 (2019-2026)	Unknown	No

Name and country of project	Distance from EA1N (km)	Distance from EA1N cable corridor (km)	Size (MW)	Maximum number of wind turbines	Date of consent (7yr construction window)	Dates of offshore construction / piling[1]	Realistic worst-case scenario of piling occurring at the same time as EA1N
Parc éolien en mer de Fécamp, France	291	235	498	83	2016 (2016-2023)	Unknown	No
SeaStar, Belgium	78	85	252	30	2014 (2014-2021)	Unknown	No
Windpark Fryslan, Netherlands	192	209	382.7	89	2018 (2018-2025)	2019-2021	No
Tier 4: application submitted or project on-hold							
Dounreay Tri, UK	106	824	10	2	2017 (2017-2024)	Unknown	No
East Anglia TWO, UK	10	6	Up to 900	Up to 75	2020 (2020-2027)	2025 - 2027	No[4]
Firth of Forth Phase 1 Seagreen Alpha & Bravo	519	516	1,500	120	2014 & 2017 (2017-2024)	2021-2024	No
ForthWind Demo Phase 1	546	541	12	2	2016 (2016-2023)	Unknown	No
Hornsea Project Three, UK	141	151	2,400	319	2019 TBC (2019-2026)	Construction: 2022-2029	Yes

Name and country of project	Distance from EA1N (km)	Distance from EA1N cable corridor (km)	Size (MW)	Maximum number of wind turbines	Date of consent (7yr construction window)	Dates of offshore construction / piling[1]	Realistic worst-case scenario of piling occurring at the same time as EA1N
						Piling: 2022-2023 and 2027-2028	
Moray Firth West, UK	710	712	750	90	2019 (2019-2026)	2022-2024 Piling: 2022-2023	No
Norfolk Boreas	51	64	1,800	90-200	2020 (2020-2027)	Construction and piling: 2025 – 2029	Yes[3]
Norfolk Vanguard, UK	38	50	1,800	90-200	2019 (2019-2026)	Construction and piling: 2024 – 2028	No[3]
Thanet Extension, UK	100	78	340	34	2019 (2019-2026)	2024-2028	No[3]
Tier 5: application in preparation							
Hornsea Project Four, UK	167	170	1,000	180	2021 (2021-2028)	Unknown	No

[1]Piling and offshore construction dates are based on the latest dates and information available.
[2]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 realistic worst-case scenario.
[3]Based on the most efficient and most likely build scenario, Vattenfall would conduct piling at only one site at a time, with no concurrent piling between Thanet Extension, Norfolk Vanguard and Norfolk Boreas. Norfolk Boreas has been chosen as has the most likely piling period overlap with East Anglia ONE North of the three Vattenfall projects, based on the most recent and publicly available information, and based on the assumption that Thanet Extension could be developed first, followed by Norfolk Vanguard and then Norfolk Boreas.
[4]Based on the most efficient and most likely build scenario, SPR would conduct piling at only one site at a time.

11.7.4.1 Potential Disturbance during Offshore Windfarm Piling

560. The commitment to the mitigation measures agreed through the MMMP for piling (***section 11.3.3***) would reduce the risk of physical injury or permanent auditory injury (PTS). As such, the proposed East Anglia ONE North project would not contribute to any cumulative impacts for physical injury or permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

11.7.4.1.1 Sensitivity to Disturbance

561. As outlined in ***section 11.6.1.4.1***, harbour porpoise, grey seal and harbour seal are assessed as having medium sensitivity to disturbance from underwater noise sources.

11.7.4.1.2 Magnitude of Cumulative Impacts

562. The magnitude of the potential disturbance 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).

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

564. 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.

565. 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.

566. 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.

567. The conservative potential worst-case scenario for offshore windfarms, in the harbour porpoise, grey seal and harbour seal reference population areas, that could be piling at the same time as in the proposed East Anglia ONE North project within the North Sea MU includes four other UK offshore windfarms (***Table 11.56***):

- Creyke Beck B;
- Sofia (formerly Teesside B);
- Hornsea Project Three; and
- Norfolk Boreas.

568. In this potential worst-case scenario, for concurrent piling at the other projects and single piling at the East Anglia ONE North windfarm site the estimated maximum area of potential disturbance is 19,116km^2, without any overlap in the potential areas of disturbance at each offshore windfarm or between offshore windfarms.

569. The maximum number of harbour porpoise that could potentially be temporarily disturbed is 16,377 individuals, which represents approximately 4.7% of the North Sea MU reference population (***Table 11.57***). Therefore, the potential magnitude of the temporary effect is assessed as low (between 1% and 5% of the reference population). However, this is very precautionary, as it is unlikely that the four projects could be concurrently piling at exactly the same time as single piling within the East Anglia ONE North windfarm site.

570. The maximum number of grey seal that could potentially be disturbed is 1,295 (5.9% of the reference population) and 47 harbour seal (0.1% of the reference population; ***Table 11.58***). The potential magnitude for the cumulative impacts of concurrent piling is assessed as medium for grey seal with less than 10% of the reference population that could be temporarily disturbed and negligible for harbour seal, with less than 1% of the reference population likely to be exposed to the effect.

571. Based on a single pile installation at each of the five offshore windfarms, the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance at each windfarm or between offshore windfarms. The maximum number of harbour porpoise that could potentially be temporarily disturbed is 8,833 individuals which represents approximately 2.6% of the North Sea MU reference population (***Table 11.57***). 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.

572. Based on a single pile installation at each of the five offshore windfarms, the maximum number of grey seal that could potentially be disturbed is 656 (3.0% of the reference population) and 24 harbour seal (0.05% of the reference population) (***Table 11.58***). 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 disturbed and negligible for harbour seal, with less than 1% of the reference population likely to be exposed to the effect.

573. The approach to the CIA, based on the five UK offshore windfarms single piling, would allow for some of these sites not to be piling at the same time while others could be concurrent piling. This is considered to be the most realistic worst-case scenario, as it is highly unlikely that the other three windfarms would be concurrently piling at exactly the same time or even on the same day as piling at East Anglia ONE North.

574. As outlined above, although the potential piling duration for the proposed East Anglia ONE North project has been assessed based on a precautionary maximum duration for construction, the actual piling time which could disturb harbour porpoise is only a very small proportion of this time, of 35.2 days, which is approximately 8.6% of the estimated construction period, based on the estimated maximum duration to install individual piles.

575. The potential temporary effects would be less than those predicted in this assessment as there is likely to be a great deal of variation in timing, duration, and hammer energy used throughout the various offshore windfarm 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% and at 21km the abundance was reduced by just 2%.

Table 11.57 Quantified CIA for the Potential Disturbance of Harbour Porpoise During Single and Concurrent Piling of Offshore Windfarms for the Realistic Worst-Case Scenario Based on the Offshore Windfarm Projects Which Could be Piling at the Same Time as Single Piling at the Proposed East Anglia ONE North project

Name of Project	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)
East Anglia ONE North	L	0.607	1,289	1,289 (single piling only)
Creyke Beck B	O	0.888	1,886	3,772

Name of Project	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Potential number of harbour porpoise disturbed during single piling (2,124km²)	Potential number of harbour porpoise disturbed during concurrent piling with no overlap (4,248km²)
Sofia	O[1]	0.888	1,886	3,772
Norfolk Boreas	O[2]	0.888	1,886	3,772
Hornsea Project Three	O	0.888	1,886	3,772
Total			**8,833**	**16,377**
% of North Sea MU reference population (345,373 harbour porpoise)			**2.6%**	**4.7%**

[1]Sofia overlaps SCANS-III survey block O and N, but majority of site is in block O; therefore, the higher density estimate from survey block O is used.
[2]Norfolk Boreas is located in both SCANS-III survey block L and survey block O; therefore, the higher density estimate from survey block O is used.

Table 11.58 Quantified CIA for the Potential Disturbance of Grey and Harbour Seal During Single and Concurrent Piling of Offshore Windfarms for the Realistic Worst-Case Scenario Based on the Offshore Windfarm Projects which could be Piling at the Same Time as East Anglia ONE North

Name of Project	Grey seal density estimate (No/km²)[1]	Harbour seal density estimate (No/km²)[1]	Potential number of grey seal disturbed		Potential number of harbour seal disturbed	
			single piling	concurrent piling	single piling	concurrent piling
East Anglia ONE North	0.008	0.0003	17	17 (single piling)	0.6	0.6 (single piling)
Creyke Beck B	0.13	0.002	276	552	4	8
Sofia	0.09	0.001	191	382	2	4
Norfolk Boreas	0.001	0.0001	2	4	0.2	0.4
Hornsea Project Three	0.08	0.008	170	340	17	34
Total			**656**	**1,295**	**24**	**47**
% of reference population (21,864 grey seal; 44,965 harbour seal)			**3.0%**	**5.9%**	**0.05%**	**0.1%**

[1]The densities included are based on a 26km buffer around the offshore windfarm, 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).

11.7.4.1.3 Cumulative Impact Significance

576. If all four offshore windfarms were concurrent piling at the same time whilst the proposed East Anglia ONE North project is single piling, there is the potential for a medium magnitude of effect, however, as outlined above, it is highly unlikely that all five offshore windfarms could be concurrently piling at exactly the same time. In addition, with the implementation of the management measures for the SNS SAC, the potential impacts could be managed (***Table 11.59***). Any mitigation measures to reduce the disturbance of harbour porpoise would also reduce the potential disturbance of grey and harbour seal.

577. Therefore, taking into account the medium receptor sensitivity for harbour porpoise and the low potential magnitude of the cumulative impact for harbour porpoise the overall assessment of **minor adverse (not significant)** for harbour porpoise is deemed to be a conservative assessment based on the realistic worst-case scenario for five offshore windfarms single piling at the same time as East Anglia ONE North (***Table 11.59***). In the unlikely event that that the four windfarms are concurrently piling at exactly the same time as piling at East Anglia ONE North, the impact significance would remain **minor adverse (not significant)** for harbour porpoise and harbour seal, but would be **moderate adverse** for grey seal

578. 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 from single piling, the overall assessment is of **minor adverse (not significant)** for grey and harbour seal for single piling (***Table 11.59***).

579. The approach to the CIA, based on the five UK offshore windfarms single piling, would allow for some of these sites not to be piling at the same time while others could be concurrent piling.

580. 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 and seal-at sea density estimates for all offshore windfarm sites.

Table 11.59 Cumulative Impact Significance for Disturbance to Harbour Porpoise, Grey Seal and Harbour Seal from Offshore Windfarms Piling During Construction at the Proposed East Anglia ONE North Windfarm Site

Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Cumulative impact of disturbance to harbour porpoise, grey seal and harbour seal during single piling at four offshore windfarms at the same time as East Anglia ONE North	Medium	Low for harbour porpoise Low for grey seal Negligible for harbour seal	Minor Minor Minor	Potential management for SNS SAC (e.g. project specific SIPs)	**Minor adverse**
Cumulative impact of disturbance to harbour porpoise, grey seal and harbour seal during concurrent piling at four offshore windfarms at the same time as single piling at East Anglia ONE North	Medium	Low for harbour porpoise Medium for grey seal Negligible for harbour seal	Minor Moderate Minor		**Minor adverse**

11.7.5 Impact 2: Underwater Noise Impacts from all other Noise Sources

581. During the construction period for the East Anglia ONE North offshore development area, there are other potential noise sources in addition to piling that could also disturb harbour porpoise, grey seal and harbour seal, these sources are:

- UXO clearance;
- Seismic surveys;
- Offshore windfarm non-piling construction activities; and
- Offshore windfarm operation and maintenance activities.

582. The CIA screening (***Appendix 11.3***) determined that it was highly unlikely that the following activities could contribute significantly to the cumulative effects of the disturbance of harbour porpoise, grey seal and harbour seal 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;
- Subsea cables and pipelines; and
- Carbon capture projects.

11.7.5.1 Potential Disturbance from all other Noise Sources

11.7.5.1.1 Sensitivity to Disturbance

583. Harbour porpoise, grey seal and harbour seal are assessed as having medium sensitivity to disturbance from underwater noise sources (***Table 11.27***).

11.7.5.1.2 Magnitude of Cumulative Impacts

11.7.5.1.2.1 UXO Clearance

584. The commitment to the mitigation measures agreed through the MMMP for UXO clearance would result in no potential effects for physical injury or permanent auditory injury (PTS). As such, the proposed East Anglia ONE North project would not contribute to any cumulative impacts for any physical injury or permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

585. This assessment has been based on the potential for disturbance from one UXO clearance in the North Sea area. Following the current SNCB advice, the CIA has been based on a distance of 26km around UXO clearance to assess the area that harbour porpoise could potentially be disturbed.

586. However, as outlined in the BEIS (2018) Review of Consents HRA, due to the nature of the sound arising from the detonation of UXO, i.e. each blast lasting for a very short duration, marine mammals, including harbour porpoise, are not predicted to be significantly displaced from an area, any changes in behaviour, if they occur, would be an instantaneous response and short-term. Existing guidance suggests that disturbance behaviour is not predicted to occur from UXO clearance if undertaken over a short period of time (JNCC 2010b).

587. It is also highly unlikely that more than one UXO detonation would occur at exactly the same time or on the same day as another UXO detonation, even if they had overlapping UXO clearance operation durations. Therefore, including the potential disturbance of 26km around one UXO detonation (2,124km^2) in this assessment is a worst-case scenario.

588. 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.

589. 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 offshore windfarms. 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 offshore windfarms (UK and EU) included within the CIA.

590. The number of harbour porpoise that could potentially be disturbed during one UXO detonation would be up to 1,105 harbour porpoise (0.3% of the NS MU reference population; ***Table 11.60***). 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.

591. The number of grey seal that could potentially be disturbed would be 212 (0.97% of the reference population; ***Table 11.60***) and the number of harbour seal would be 43 (0.1% of the reference population; ***Table 11.60***). The potential magnitude of the temporary effect is assessed as negligible grey seal and harbour seal with less than 1% of the reference population likely to be exposed to the effect.

Table 11.60 Quantified CIA for the Potential Disturbance of Harbour Porpoise, Grey Seal and Harbour Seal During UXO Clearance Operations in the North Sea During Construction at East Anglia ONE North

UXO clearance	Area of potential disturbance	Potential number of harbour porpoise disturbed	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
Disturbance from one UXO clearance operation in the North Sea area	2,124km^2	1,105 (0.3% NS MU)	212 (0.97% ref pop)	43 (0.1% ref pop)

11.7.5.1.2.2 Seismic surveys

592. 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 within the East Anglia ONE North offshore development area.

593. It is therefore assumed, as a worst-case scenario, that there could potentially be up to two seismic surveys in the North Sea at any one time. As outlined in the BEIS (2018) draft RoC HRA, between 2005 and 2015 there were 40 seismic surveys in the SNS SAC during the summer and winter periods, resulting in an average of four surveys per year. The average number of days per year was 61.3 days (up to 17% of 365 days per year). Taking this into account, it is unlikely that two or more seismic surveys will be conducted in the southern North Sea at exactly the same time.

594. Following the current SNCB advice, the CIA has been based on the following worst-case parameter:

- A distance of 10km around seismic surveys has been used to assess the area that harbour porpoise could potentially be disturbed (314km^2).

595. This approach has also been used for the potential disturbance of grey and harbour seal.

596. It should be noted that this assessment is based on the potential impacts for seismic surveys required by the oil and gas industry. The higher frequencies typically used for surveys for offshore windfarms generally 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 2017a).

597. 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 seismic survey this has been used to estimate the potential number of harbour porpoise that could potentially be disturbed.

598. 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 offshore windfarms. As outlined above, this is 0.1 grey seal per km^2 and 0.02 harbour seal per km^2.

599. The realistic worst-case scenario of two seismic surveys (628km^2) could potentially disturb up to 326 harbour porpoise (approximately 0.09% of the reference population). Therefore, the magnitude would be negligible (less than 1% of reference population likely to be disturbed).

600. Two seismic surveys (628km^2) 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.

Table 11.61 Quantified CIA for the Potential Disturbance of Harbour Porpoise, Grey Seal and Harbour Seal During Seismic Surveys in the North Sea During Construction of the Proposed East Anglia ONE North Project

Seismic surveys	Area of potential disturbance	Potential number of harbour porpoise disturbed	Potential number of grey seal disturbed	Potential number of harbour seal disturbed
Disturbance from two seismic surveys in the North Sea area	628km^2	326 (0.09% NS MU)	63 (0.3% ref pop)	13 (0.03% ref pop)

11.7.5.1.2.3 Offshore windfarm construction

601. During the construction of the proposed East Anglia ONE North project, there is the potential to overlap with impacts from the non-piling construction activities, at other offshore windfarms. Noise sources which could cause potential disturbance impacts during offshore windfarm 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.

602. There would be no additional cumulative impacts of underwater noise from other construction activities for those projects which also have overlapping piling with East Anglia ONE North as the ranges for piling would be significantly greater than those from other construction noise sources.

603. The potential impact ranges of these noise sources during offshore windfarm construction will be localised and significantly less than the ranges predicted for piling.

604. The CIA determined the UK and European offshore windfarms which could potentially have non-piling construction activities during the East Anglia ONE North construction period (***Table 11.56***). This precautionary realistic worst-case scenario, includes five other UK offshore windfarms that could have non-piling construction activities during the East Anglia ONE North construction period:

- Creyke Beck A;
- Teesside A;
- Thanet Extension;
- Norfolk Vanguard; and
- East Anglia TWO.

605. The potential temporary disturbance during offshore windfarm construction activities, other than pile driving noise sources, has been based on the area of

the offshore windfarm sites. This is a very precautionary approach, as it is highly unlikely that non-piling construction activities would result in disturbance from entire windfarm sites. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place.

606. In addition, it is unlikely, as outlined for the cumulative impact assessment for piling, that developers would construct more than one offshore windfarm at a time as it is generally more efficient to develop one site and have it operational prior to constructing the next site. In addition, the UK government funding mechanism for offshore wind (Contracts for Difference auctions) also makes it more unlikely that developers would be constructing more than one windfarm concurrently.

607. The assessment indicates that if all five of these offshore windfarms were conducting non-piling construction activities at the same time, the estimated maximum cumulative area of disturbance is 1,960km^2 (based on disturbance from the entire offshore windfarm area) and the maximum number of harbour porpoise that could potentially be disturbed is 1,629 individuals, which represents approximately 0.5% of the North Sea MU reference population (***Table 11.62***). 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.

608. The maximum number of grey seal that could potentially be disturbed is 36.5 individuals, which represents approximately 0.2% of the reference population (***Table 11.63)***. 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.

609. The maximum number of harbour seal that could potentially be disturbed is up to 4.8 individuals, which represents approximately 0.01% of the reference population (***Table 11.63)***. 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 11.62 Quantified CIA for the Potential Disturbance of Harbour Porpoise During Non-Piling Construction Activities at UK and European Offshore Windfarms During Construction for the Proposed East Anglia ONE North Project

Name of Project	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Area of Wind Farm (WF) site (km²)*	Potential number of harbour porpoise disturbed from entire WF area
Creyke Beck A	O	0.888	515	457
Teesside A	N	0.837	562	470
Thanet Extension	L	0.607	73	44
Norfolk Vanguard	O[1]	0.888	592	526
East Anglia TWO	L	0.607	218	132
Total			**1,960**	**1,629**
% of North Sea MU reference population (345,373 harbour porpoise)				**0.5%**

**Source: http://www.4coffshore.com/*
[1]Norfolk Vanguard overlaps SCANS-III survey block O and L; therefore, higher density estimate from survey block O is used.

Table 11.63 Quantified CIA for the Potential Disturbance of Grey and Harbour Seal During Non-Piling Construction Activities at offshore windfarms during construction for the Proposed East Anglia ONE North Project

Name of Project	Grey seal density estimate (No/km²)[1]	Harbour seal density estimate (No/km²)[1]	Area of WF site (km²)*	Potential number of grey seal disturbed from entire WF area	Potential number of harbour seal disturbed from entire WF area
Creyke Beck A	0.05	0.0004	515	26	0.2
Teesside A	0.013	0.00004	562	7.3	0.02
Thanet Extension	0.02	0.06	73	1.5	4.4
Norfolk Vanguard	0.001	0.00008	592	0.6	0.05
East Anglia TWO	0.005	0.0004	218	1.1	0.1
Total			**1,960**	**36.5**	**4.8**
% of reference population (21,864 grey seal; 44,965 harbour seal)				**0.17%**	**0.01%**

**Source: http://www.4coffshore.com/*
[1]Density is based on grids overlapping with the project only (Source: Russell et al. 2017).

11.7.5.1.2.4 Offshore windfarm operation and maintenance

610. There is the potential for disturbance from other offshore windfarms that have already been constructed as a result of any operational and maintenance activities, including vessels, during the construction period for the proposed East Anglia ONE north project. The potential disturbance from operational offshore windfarms and maintenance activities could include the operational wind turbines, vessels, any rock dumping or cable re-burial.

611. As outlined in ***sections 11.6.2.1***, ***11.6.2.2*** and ***11.6.2.3***, any potential disturbance as a result of underwater noise from these activities will be temporary and limited to the area around the activity. However, as a precautionary approach the assessment has been based on entire offshore windfarm site areas, although it is highly unlikely that operational offshore windfarms and maintenance activities, including vessels, would result in disturbance from the entire windfarm area. There is currently no evidence of any significant disturbance of harbour porpoise from operational windfarm sites.

612. Operational offshore windfarms were considered part of the baseline if they were operational at the time of the start of the East Anglia ONE North site specific surveys (September 2016). Therefore, offshore windfarms were screened into the CIA as having the potential to be newly operational by the East Anglia ONE North construction period, in that they are currently under construction or will be constructed and operational by 2026. The projects were located in the relevant areas for the reference populations used in the CIA for harbour porpoise, grey seal and harbour seal.

613. Operational UK and European offshore windfarms that could have potential cumulative impacts during the construction period for the proposed East Anglia ONE North project have an estimated maximum potential cumulative area up to 4,813km^2 (based on disturbance from entire offshore windfarm area) and the maximum number of harbour porpoise that could be temporarily disturbed would be up to 2,730 individuals which represents approximately 0.79% of the North Sea MU reference population (***Table 11.64***). 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.

614. The maximum number of grey seal that could potentially be disturbed is 271 individuals, which represents approximately 1.2% of the reference population (***Table 11.65)***. 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.

615. The maximum number of harbour seal that could potentially be disturbed is 119.5 individuals, which represents approximately 0.3% of the reference population

(***Table 11.65)***. 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 11.64 Quantified CIA for the Potential Disturbance of Harbour Porpoise During Operation and Maintenance Activities at Offshore Windfarms During Construction at the Proposed East Anglia ONE North Project

Name of Project	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of WF site (km^2)*	Potential number of harbour porpoise disturbed
Beatrice	S	0.152	131	20
Blyth Offshore Wind Demo 2[1]	R	0.599	<1	1
Blyth Offshore Wind Demo 3A & 4[2]	R	0.599	4	2
Borkum Riffgrund II[2]	N	0.837	36	30
Borkum Riffgrund West I[2]	N	0.837	30	25
Borkum Riffgrund West II[2]	N[3]	0.837	16	13
Borssele I and II	N	0.837	113	95
Borssele III and IV	N	0.837	122	102
Borssele Site V	N	0.837	1	1
Deutsche Bucht (DeBu)	N	0.837	18	15
Dounreay Tri	S	0.152	25	4
Dudgeon[1]	O	0.888	55	49
East Anglia ONE	L	0.607	205	124
East Anglia THREE	L	0.607	301	183
EnBW He Dreiht	M	0.277	62	17
EnBW Hohe See (Hochsee Windpark 'Nordsee')	M	0.277	40	11
Eoliennes du Calvados	C	0.213	78	17
European Offshore Wind Deployment Centre EOWDC (Aberdeen Demonstration)	R	0.599	20	12

Name of Project	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Area of WF site (km²)*	Potential number of harbour porpoise disturbed
Firth of Forth Phase 1 Seagreen Alpha & Bravo	5	0.599	391	234
ForthWind Demo Phase 1	R	0.599	9	5
Galloper[1]	L	0.607	113	69
Gemini[1]	N	0.837	70	59
Global Tech I	M	0.277	42	12
Gode Wind 1 and 2[1]	M	0.277	70	19
Gode Wind 03[2]	M	0.277	4	1
Gode Wind 04[2]	M	0.277	29	8
Hollandse Kust Zuid Holland II[2]	N	0.837	103	86
Horns Rev 3[2]	M	0.277	144	40
Hornsea Project One	O	0.888	407	361
Hornsea Project Two	O	0.888	462	410
Hywind – Pilot Park[1]	R	0.599	15	9
Inch Cape	R	0.599	15	9
Kaskasi[2]	M	0.277	17	5
Kincardine	R	0.599	110	66
KvitsØy Wind Turbine Demonstration Area[2]	V	0.137	<1	0
Makani Floating Wind Turbine	V	0.137	1	0.1
Merkur[2]	M	0.277	39	11
Mermaid	N	0.837	16	13
Moray Firth East	S	0.152	295	45
Moray Firth West	S	0.152	226	34
Neart na Gaoithe	R	0.599	105	63
Nissum Bredning Vind	P	0.823	5	4

Name of Project	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of WF site (km^2)*	Potential number of harbour porpoise disturbed
Nobelwind	N	0.837	22	18
Nordergruende[1]	M	0.277	3	1
Nordsee One (Innogy Nordsee I)	M	0.277	31	9
Norther[2]	L	0.607	38	23
Northwester 2[2]	L	0.607	12	7
OWP Albatros	M	0.277	11	3
OWP West[2]	N	0.837	14	12
Parc éolien en mer de Dieppe – Le Treport	C	0.213	150[3]	32
Parc éolien en mer de Fécamp	C	0.213	88	19
Race Bank[1]	O	0.888	62	55
Rampion Wind Farm	C	0.213	79	17
RennesØy Wind Turbine Demonstration Area[2]	V	0.137	1	0
RENTEL[2]	L	0.607	23	14
Sandbank[1]	M	0.277	47	13
Seastar	L	0.607	20	12
Trianel Windpark Borkum Phase 2 (aka Borkum West II phase 2)	M	0.277	33	9
Triton Knoll phase 1-3	O	0.888	146	130

Name of Project	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of WF site (km^2)*	Potential number of harbour porpoise disturbed
Veja Mate[1]	N	0.837	51	43
Windpark Fryslan	N	0.837	35	29
Total			**4,813km^2**	**2,730**
% of North Sea MU reference population (345,373 harbour porpoise)				**0.79%**

**Source: http://www.4coffshore.com/*
[1]Operational after the start of the East Anglia ONE North site specific surveys, but before the submission of the PEI
[2]Unknown date of project operation, but assumed to be before the construction of East Anglia ONE North
[3]estimated from http://www.4coffshore.com/

Table 11.65 Quantified CIA for the Potential Disturbance of Grey and Harbour Seal During Operation and Maintenance Activities at Offshore Windfarms During Construction for the Proposed East Anglia ONE North Project

Name of Project	Grey seal density estimate (No/km^2)[1]	Harbour seal density estimate (No/km^2)[1]	Area of WF site (km^2)*	Potential number of grey seal disturbed from entire WF area	Potential number of harbour seal disturbed from entire WF area
Blyth Offshore Wind Demo 2[2]	0.015	N/A	<1	0.02	N/A
Blyth Offshore Wind Demo 3A & 4[2]	0.06	N/A	4	0.2	N/A
Dudgeon[1]	0.11	0.2	55	6	11
East Anglia ONE	0.0006	0.0003	205	0.1	0.06
East Anglia THREE	0.0001	0.001	301	0.03	0.3
Galloper[2]	0.007	0.001	113	0.7	0.1
Hornsea Project One	0.4	0.05	407	164	19
Hornsea Project Two	0.17	0.08	462	80	36
Nordergruende	0	0	3	0	0
Norther[2]	0.0003	0.0001	38	0.01	0.004
Northwester 2[3]	0.0004	0.0002	15	0.006	0.003

Name of Project	Grey seal density estimate (No/km²)[1]	Harbour seal density estimate (No/km²)[1]	Area of WF site (km²)*	Potential number of grey seal disturbed from entire WF area	Potential number of harbour seal disturbed from entire WF area
Race Bank	0.08	0.19	62	5	12
RENTEL[2]	0.0004	0.0002	23	0.009	0.005
Triton Knoll phase 1-3	0.1	0.28	146	15	41
Total			**1,835**	**271**	**119.5**
% of reference population (21,864 grey seal; 44,965 harbour seal)				**1.2%**	**0.3%**

**Source: http://www.4coffshore.com/*
[1]Density is based on grids overlapping with the project only (source: Russell et al. 2017)
[2]Operational after the start of the East Anglia ONE North site specific surveys, but before the submission of the PEI
[3]Unknown date of project operation, but assumed to be before the construction of East Anglia ONE North

11.7.5.1.2.5 Overall magnitude of cumulative impacts from non-piling noise sources

616. The maximum number of harbour porpoise that could potentially be temporarily disturbed as a result of underwater noise from all other non-piling potential noise sources and activities, at other offshore windfarms, during construction, including piling at the East Anglia ONE North windfarm site is 5,790 individuals, which represents 1.7% of the North Sea MU reference population (***Table 11.66***). 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.

617. 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 11.67)***.

618. This assessment is based on highly conservative assumptions (e.g. displacement of all harbour porpoise and seals from the boundary of each offshore windfarm and the assumption that there is no overlap from the disturbance impacts listed).

Table 11.66 Quantified CIA for the Potential Disturbance of Harbour Porpoise from All Possible Noise Sources (Other than offshore windfarm Piling) During Offshore Construction for the Proposed East Anglia ONE North Project

Potential noise sources	Area of potential disturbance	Potential number of harbour porpoise disturbed
UXO clearance (one detonation at a time)	2,124km^2	1,105
Seismic surveys (up to 2 surveys)	628km^2	326
Offshore windfarm non-piling construction activities	1,960km^2	1,629
Operation and maintenance of offshore windfarms	4,813km^2	2,730
Total for other noise sources (excluding piling)	**9,525km^2**	**5,790**
% of NS MU reference population (345,373 harbour porpoise)		**1.7%**

Table 11.67 Quantified CIA for the Potential Disturbance of Grey Seal and Harbour Seal from All Possible Non-Piling Noise Sources During Construction for the Proposed East Anglia ONE North project

Potential noise sources	Area of potential disturbance	Potential number of grey seal impacted	Potential number of harbour seal impacted
UXO clearance (one detonation at a time)	2,124km^2	212	43
Seismic surveys (up to 2 surveys)	628km^2	63	13
Offshore windfarm construction non-piling activities	1,960km^2	36.5	4.8
Operation and maintenance of offshore windfarms	1,835km^2	271	119.5
Total	**6,547km^2**	**582.5**	**180.3**
% of reference population (21,864 grey seal; 44,965 harbour seal)		**2.7%**	**0.4%**

11.7.5.1.3 Cumulative Impact Significance

619. ***Table 11.68*** summarises the potential cumulative impact significance for disturbance to harbour porpoise from other noise sources during the construction of the proposed East Anglia ONE North project. Based on medium sensitivity and low magnitude of effect resulting from cumulative noise sources, the impact significance would be **minor adverse (not significant)** for harbour porpoise.

620. Based on medium sensitivity and low magnitude of effect resulting from cumulative noise sources excluding piling, the impact significance is assessed as

minor adverse (not significant) for grey seal. The overall magnitude for harbour seal is negligible, resulting in a **minor adverse (not significant)** effect.

621. As outlined previously, the approach to this assessment is very precautionary, based on entire windfarm areas for non-piling construction activities, operational windfarms and maintenance activities, when the area of potential disturbance will be limited to the area around the activity.

622. The confidence that this impact assessment is precautionary enough to comfortably encompass the likely uncertainty and variability is high.

Table 11.68 Cumulative Impact Significance for Disturbance to Harbour Porpoise, Grey Seal and Harbour Seal from Other Noise Sources During Construction and Piling for the Proposed East Anglia ONE North Project

Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
All possible noise sources excluding piling	Medium	Low for harbour porpoise Low for grey seal Negligible for harbour seal	Minor adverse for harbour porpoise, grey seal and harbour seal	No additional mitigation required, although project specific SIPs for SNS SAC may further reduce magnitude of effect, ir required.	**Minor adverse**

11.7.6 Summary of the Cumulative Underwater Noise Impacts (Impacts 1 and 2)

11.7.6.1 Magnitude of Cumulative Impacts

623. 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 piling at the East Anglia ONE North windfarm site as the impact ranges for piling would be significantly greater than those impacts from other construction noise sources.

624. The potential cumulative impacts from all noise sources that could be occurring at the same time as construction of the proposed East Anglia ONE North project are summarised in ***Table 11.69***.

625. 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.

626. This assessment is based on highly conservative assumptions (e.g. displacement of all marine mammals from the boundary of each offshore windfarm and the assumption that there is no overlap from the disturbance impacts listed).

Table 11.69 Quantified CIA for the Potential Disturbance of Marine Mammals from all Possible Noise Sources Including Piling During Construction and Piling for the Proposed East Anglia ONE North Project

Potential noise sources	Area of potential disturbance	Potential number of harbour porpoise impacted	Potential number of grey seal impacted	Potential number of harbour seal impacted
Offshore windfarm projects, including East Anglia ONE North, with the potential of single piling at the same time	10,620km^2	8,833	656	24
UXO clearance (one detonation at a time)	2,124km^2	1,105	212	43
Seismic surveys (up to 2 surveys)	628km^2	326	63	13
Offshore windfarm non-piling construction activities	1,960km^2	1,629	36.5	4.8
Operation and maintenance of offshore windfarms	4,813km^2 for harbour porpoise 1,835km^2 for grey and harbour seal	2,730	271	119.5
Total		**14,623**	**1,238.5**	**204.3**
% of reference population (345,373 harbour porpoise; 21,864 grey seal; 44,965 harbour seal)		**4.2%**	**5.7%**	**0.5%**

11.7.6.2 Cumulative Impact Significance

627. Based on medium sensitivity and low magnitude of effect resulting from cumulative noise sources, the impact significance is assessed as **minor adverse** for harbour porpoise. Based on medium sensitivity and medium magnitude of effect resulting from cumulative noise sources, the impact significance is assessed as potentially **moderate adverse** for grey seal. The overall magnitude for harbour seal is negligible, resulting in a **minor adverse** significance.

11.7.6.2.1 Mitigation

628. The contribution of the proposed East Anglia ONE North project to the overall cumulative impact from underwater noise, during single pile installation (***Table 11.57***), would potentially be the disturbance of up to 1,289 harbour porpoise, approximately 8.8% of the total 14,623 harbour porpoise that could be disturbed; the disturbance of up to 17 grey seal, approximately 1.4% of the total of 1,238.5 grey seal that could be disturbed; and the disturbance of 0.6 harbour seal, approximately 0.3% of the 204.3 harbour seal that could be disturbed.

629. In order to address the overall cumulative impact, a wider management approach (such as a SIP for each project as proposed by the BEIS (2018) draft RoC HRA for the SNS SAC) may be required dependent upon future management measures developed for the SNS SAC.

11.7.6.2.2 Residual impact

630. It is anticipated that by working with the Natural England and the Marine Management Organisation to develop suitable mitigation measures and a possible strategic approach, the potential cumulative impacts of construction noise, including piling, would result in a **minor adverse** (not significant) impact on grey seal.

Table 11.70 Cumulative Impact Significance for Disturbance to Harbour Porpoise, Grey Seal and Harbour Seal from all Potential Noise Sources During Construction and Piling for the Proposed East Anglia ONE North Project.

Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
All possible noise sources during construction and piling at East Anglia ONE North	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	Project specific SIPs for SNS SAC, if required.	**Minor adverse**

11.7.7 Impact 3: Changes to Prey Resources

631. As outlined in **section 11.7.2.2**, 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 cumulative impacts other than those assessed for marine mammals, i.e. if prey species 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.

632. 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.

11.7.8 Impact 4: Vessel and other Interactions

11.7.8.1 Sensitivity

633. As outlined in ***section 11.6.1.8***, marine mammals in the East Anglia ONE North offshore development 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.

11.7.8.2 Magnitude

634. During the construction of offshore windfarms, 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 windfarm site only. 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.

635. As a precautionary approach, the number of harbour porpoise, grey seal and harbour seal that could be at increased collision risk with vessels has been assessed based on 5% of the individuals in the offshore windfarm areas could be at increased risk. This has been based on the offshore windfarms that could be constructing at the same time as the proposed East Anglia ONE North project. This is very precautionary, as it is highly unlikely that all marine mammals present in all windfarm areas would be at increased collision risk with vessels.

636. The number of harbour porpoise that could have a potential increased collision risk with vessels in offshore windfarm sites could be 204 individuals, which represents 0.06% of the NS MU reference population (***Table 11.71***). 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.

637. The number of grey seal that could have a potential increased collision risk with vessels in offshore windfarm sites could be 10.4 individuals, which represents 0.05% of the reference population (***Table 11.72***). 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.

638. The number of harbour seal that could have a potential increased collision risk with vessels in offshore windfarm sites could be 0.6, which represents 0.001% of the reference population (***Table 11.72***). 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.

639. Any increase in vessel movements during the operation and maintenance of offshore windfarms 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 offshore windfarms and as a result this has not been included in the CIA.

640. 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.

641. All other projects identified in the CIA screening (***Appendix 11.3***) have the potential to increase vessel activity over the range of each species, although most of these projects were already active and therefore considered part of the baseline, including vessel movements. Therefore, for any additional projects any increase in vessel movements is likely to be relatively small in relation to current ship movements in the area and as a result this has not been included in the CIA.

Table 11.71 Quantified CIA for the Potential Increased Collision Risk with Vessels for Harbour Porpoise During Offshore Windfarm Construction

Name of Project	Tier	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of WF site*	Potential number of harbour porpoise impacted based on 5% increased collision risk
East Anglia ONE North	5	L	0.607	208	6
Creyke Beck A	3	O	0.888	515	23
Creyke Beck B	3	O	0.888	599	27
Teesside A	3	N	0.837	562	24
Sofia	3	O[2]	0.888	593	26
Norfolk Vanguard	4	O[3]	0.888	592	26
Hornsea Project Three	4	O	0.888	695	31
Thanet Extension	4	L	0.607	73	2
Norfolk Boreas	5	O[1]	0.888	725	32
East Anglia TWO	5	L	0.607	218	7
Total				**4,780km^2**	**204**
% of NS MU reference population (345,373 harbour porpoise)					**0.06%**

[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 and N, but majority of site is in block O.
[3]Norfolk Boreas overlaps SCANS-III survey block O and L; therefore, higher density estimate from survey block O is used.
**Source: http://www.4coffshore.com/*

Table 11.72 Quantified CIA for the Potential Increased Collision Risk with Vessels for Grey Seal and Harbour Seal During Offshore Windfarm Construction

Name of Project	Grey seal density estimate (No/km^2)[1]	Harbour seal density estimate (No/km^2)[1]	Area of WF site (km^2)*	Potential number of grey seal impacted based on 5% collision risk	Potential number of harbour seal impacted based on 5% collision risk
East Anglia ONE North	0.0009	0.0004	208	0.01	0.004
Creyke Beck A	0.05	0.0004	515	1.3	0.01
Creyke Beck B	0.2	0.008	599	6	0.2

Name of Project	Grey seal density estimate (No/km²)[1]	Harbour seal density estimate (No/km²)[1]	Area of WF site (km²)*	Potential number of grey seal impacted based on 5% collision risk	Potential number of harbour seal impacted based on 5% collision risk
Teesside A	0.013	0.00004	562	0.4	0.001
Sofia	0.04	0.00004	594	1.2	0.001
East Anglia THREE	0.0001	0.001	301	0.0015	0.02
Norfolk Vanguard	0.0013	0.0001	592	0.04	0.003
Hornsea Project Three	0.04	0.002	695	1.4	0.07
Thanet Extension	0.02	0.06	73	0.07	0.2
Norfolk Boreas	0.0006	0.00006	725	0.02	0.002
East Anglia TWO	0.005	0.0004	218	0.05	0.004
Total				**10.4**	**0.6**
% of reference population (21,864 grey seal; 44,965 harbour seal)				**0.05%**	**0.001%**

[1]*Density is based on grids overlapping with the project only (source: Russell et al. 2017)*

11.7.8.3 Cumulative Impact Significance

642. 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 minor adverse for the three species (***Table 11.73***).

Table 11.73 Cumulative Assessment of Impact Significance of Increased Collision Risk from Vessels During Offshore Windfarm Construction

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Increased collision risk from vessels during offshore windfarm construction	Harbour porpoise	Low	Medium	Minor adverse	No mitigation required or proposed.	**Minor adverse**
	Grey seal	Low	Medium	Minor adverse		**Minor adverse**
	Harbour seal	Low	Low	Minor adverse		**Minor adverse**

11.8 Transboundary Impacts

643. The highly mobile nature of marine mammal 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 (***Table 11.74***).

Table 11.74 List of Other EU Member States Retained in the Transboundary Impact Assessment in Relation to the Topic

EU member state	Commentary
Netherlands	Part of North MU area for harbour porpoise. Part of reference population area for grey seal. Part of reference population area for harbour seal.
Germany	Part of North MU area for harbour porpoise. Part of reference population area for grey seal. Part of reference population area for harbour seal.
France	Part of North MU area for harbour porpoise. Part of reference population area for grey seal. Part of reference population area for harbour seal.
Belgium	Part of North MU area for harbour porpoise. Part of reference population area for grey seal. Part of reference population area for harbour seal.
Denmark	Part of North MU area for harbour porpoise. Part of reference population area for grey seal.
Sweden	Part of North MU area for harbour porpoise.

644. There is a significant level of marine development being undertaken or planned by other EU Member States (i.e. Belgium, the Netherlands, Germany and Denmark) in the southern North Sea, with each having their own independent environmental assessment requirements and controls. Populations of marine mammals (particularly cetaceans) are highly mobile and there is potential for transboundary impacts especially with regard to noise. In addition, there is potential for the proposed East Anglia ONE North project to impact on marine mammals from international designated sites.

645. Transboundary impacts have been assessed with the other cumulative impacts and the Applicant has, wherever possible, liaised with developers in other

Member States to obtain up to date project information to feed into this assessment.

11.9 Inter-relationships

646. Inter-relationships are covered as part of the assessment. ***Table 11.75*** serves as a sign-posting for inter-relationships.

Table 11.75 Marine Mammal Inter-Relationships

Topic and description	Related Chapter	Where addressed in this Chapter	Rationale
Changes to prey resources	***Chapter 10 Fish and Shellfish Ecology***	***Section 11.6.1.9*** ***Section 11.6.2.5*** ***Section 11.6.3.6***	Potential impacts on fish and shellfish could affect the prey resource for marine mammals
Disturbance from vessels	***Chapter 14 Shipping and Navigation***	***Section 11.6.1.6*** ***Section 11.6.2.3*** ***Section 11.6.3.3***	Increased vessel traffic associated with the project could affect the level of disturbance for marine mammals
Vessel interaction (collision risk)	***Chapter 14 Shipping and Navigation***	***Section 11.6.1.8*** ***Section 11.6.2.4*** ***Section 11.6.3.5***	Increased vessel traffic associated with the project could affect the level of collision risk for marine mammals

11.10 Interactions

647. 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 areas of interaction between impacts are presented in ***Table 11.76***, ***Table 11.77*** and ***Table 11.78***, along with an indication as to whether the interaction may give rise to synergistic impacts. This provides a screening tool for which impacts have the potential to interact.

648. ***Table 11.79*** then provides an assessment for each receptor (or receptor group) related to these impacts in two ways. Firstly, the impacts are considered within a development phase (i.e. construction, operation or decommissioning) to see if, for example, multiple construction impacts could combine. Secondly, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across development phases. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect; the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to be additive it is the magnitude of effect which is important – the magnitudes of the different effects are combined upon

the same sensitivity receptor. If minor impact and minor impact were added this would effectively double count the sensitivity.

Table 11.76 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 non-piling construction activities	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 Changes to prey resource
1 Physical and auditory injury resulting from the underwater noise associated with UXO clearance		Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2 Behavioural impacts resulting from the underwater noise associated with UXO clearance	Yes		Yes	Yes	Yes	Yes	Yes	No	Yes
3 Physical and auditory injury resulting from underwater noise during piling	Yes	Yes		Yes	Yes	Yes	Yes	No	Yes

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 non-piling construction activities	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 Changes to prey resource
4 Behavioural impacts resulting from underwater noise during piling	Yes	Yes	Ye		Yes	Yes	Yes	No	Yes
5 Behavioural impacts resulting from underwater noise during non-piling construction activities	Yes	Yes	Yes	Yes		Yes	Yes	No	Yes
6 Behavioural impacts resulting from underwater noise and presence of vessels	Yes	Yes	Yes	Yes	Yes		Yes	No	Yes
7 Barrier effects as a result of behavioural impacts resulting	Yes	Yes	Yes	Yes	Yes	Yes		No	Yes

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 non-piling construction activities	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 Changes to prey resource
from underwater noise associated with UXO clearance, piling, construction activities and vessels									
8 Vessel interaction (collision risk)	No	No	No	No	No	No	No		No
9 Changes to prey resource	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	

Table 11.77 Interaction Between Impacts During Operation and Maintenance

Potential interaction between impacts					
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 Changes to prey resource
1 Behavioural impacts resulting from the underwater noise associated with operational turbines		Yes	Yes	No	Yes
2 Behavioural impacts resulting from the underwater noise associated with maintenance activities	Yes		Yes	No	Yes
3 Behavioural impacts resulting from underwater noise and presence of vessels	Yes	Yes		No	Yes
4 Vessel interaction (collision risk)	No	No	No		No
5 Changes to prey resource	Yes	Yes	Yes	No	

Table 11.78 Interaction Between Impacts During Decommissioning

Potential interaction between impacts
Decommissioning
It is anticipated that the decommissioning impacts will be similar to those of construction.

Table 11.79 Potential Interactions Between Impacts on Marine Mammals

	Highest level significance				
Receptor	**Construction**	**Operational**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
Harbour Porpoise, grey seal and harbour seal	Minor adverse	Minor adverse	Minor adverse	**No greater than individually assessed impact** ***Construction*** The MMMP mitigation (for both UXO and piling) will reduce the risk of injury for mammals and therefore during UXO clearance or piling there will be no pathway for interaction of potential injury with disturbance effects (i.e. all individuals are assumed to be disturbed if within range and excluded from the disturbance footprint). Likewise, there is no pathway for vessel interaction or effects on prey resource to interact with noise impacts as it is assumed that individuals will be excluded from the disturbance footprint (i.e. there cannot be a vessel interaction if the individual is excluded from the vicinity of the construction works). Once noisy activities have ceased the footprint of disturbance and changes to prey resource will be highly localised. It is therefore considered that the interaction of these impacts would not represent an increase in the significance level. *Operation* Operational noise impacts from wind turbines will be highly localised to within	**No greater than individually assessed impact** The greatest magnitude of effect will be the spatial footprint of construction noise (i.e. UXO clearance and piling). Once this disturbance impact has ceased all further impact during construction and operation will be small scale, highly localised and episodic. There is no evidence of long term displacement of marine mammals from operational windfarms. It is therefore considered that over the project lifetime these impacts would not combine and represent an increase in the significance level.

	Highest level significance				
Receptor	**Construction**	**Operational**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
				0.1km of each wind turbine, whilst the majority of change to habitat for prey species will also be confined to the immediate footprint of wind turbine. The magnitude of effect is negligible and relates to largely the same spatial footprint. Therefore, there is no greater impact as a result of any interaction of these impacts. There is potential for interaction with maintenance noise disturbance and vessel interaction, but given the negligible magnitudes of effect and episodic nature of these impacts it is not considered that that the interaction of these impacts would not represent an increase in the significance level	

11.11 Summary

649. As has been described throughout this assessment, aspects of offshore windfarm construction, operation and decommissioning that marine mammals are sensitive to include underwater noise causing potential physical and auditory injuries or behavioural changes, barrier effects (preventing movement of animals), collision risk with vessels and changes to prey availability. The impact assessment concluded that only minor impacts to marine mammals would occur as a result of construction, operation and decommissioning of the proposed East Anglia ONE North project, following implementation of the recommended mitigation measures (for example implementation of a MMMP and SIP and exercising good practice). A draft MMMP and in principle SIP have been submitted with the DCO application.

650. The potential impacts on marine mammals during the construction, operation and decommissioning phases of the proposed East Anglia ONE North project are summarised in ***Table 11.80***.

651. There are potential cumulative impacts with other offshore windfarms as a result of underwater noise from pile driving, potential changes to prey availability and increased chance of vessel interaction. These impacts have the potential to affect all three species of marine mammal assessed. However, considering the low density of these species across the offshore development area, and a commitment to implement mitigation measures (for example following a MMMP, SIP and exercising best practice), the cumulative impact on these species was assessed as minor. The potential cumulative impacts during the offshore construction of the proposed East Anglia ONE North project are summarised in ***Table 11.81.***

Table 11.80 Summary of Potential Impacts for Marine Mammals During Construction, Operation and Decommissioning of the Proposed East Anglia ONE North Project

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measure	Residual Impact
Construction						
Impact 1: Physical and Auditory Injury Resulting from the Underwater Noise Associated with UXO Clearance						
Permanent auditory injury (PTS)	Harbour porpoise	High	Medium to low	Major to moderate adverse	MMMP for UXO clearance.	**Minor adverse**
	Grey seal	High	Low	Moderate adverse		**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measure	Residual Impact
	Harbour seal	High	Negligible	Minor adverse		**Minor adverse**
Temporary auditory injury (TTS) and fleeing response during underwater UXO clearance	Harbour porpoise	Medium	Negligible	Minor adverse	MMMP for UXO clearance	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Impact 2: Behavioural Impacts Resulting from the Underwater Noise Associated with UXO Clearance						
Disturbance	Harbour porpoise	Medium	Negligible	Minor adverse	No further mitigation other than SIP for SNS SAC, if required	**Minor adverse**
	Grey seal	Medium	Negligible	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Impact 3: Physical and Auditory Injury Resulting from Underwater Noise during Piling						
PTS from single strike of starting hammer energy	Harbour porpoise, grey seal and harbour seal	High	Negligible	Minor adverse	MMMP for piling	**Minor adverse**
PTS from single strike of maximum hammer energy	Harbour porpoise, grey seal and harbour seal	High	Negligible	Minor adverse	MMMP for piling including embedded mitigation	**Minor adverse**
	Harbour porpoise	High	Medium	Major adverse	MMMP for piling including	**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measure	Residual Impact
PTS from Cumulative SEL	Grey seal	High	Negligible	Minor adverse	embedded mitigation	**Minor adverse**
	Harbour seal	High	Negligible	Minor adverse		**Minor adverse**
TTS and fleeing response	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse	MMMP for piling including embedded mitigation	**Minor adverse**
Impact 4: Behavioural Impacts Resulting from Underwater Noise During Piling						
Disturbance during piling for single installation	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse	MMMP and SIP for SNS SAC	**Minor adverse**
Possible behavioural response	Harbour porpoise	Low	Negligible	Negligible		**Negligible**
Impact 5: Potential Impacts Resulting from Underwater Noise During Other Construction Activities						
PTS from Cumulative SEL	Harbour porpoise, grey seal and harbour seal	High	Negligible	Minor adverse	No mitigation required	**Minor adverse**
TTS from Cumulative SEL	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse	No mitigation required	**Minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measure	Residual Impact
Possible behavioural response	Harbour porpoise	Low	Negligible	Negligible	No mitigation required	**Negligible**
Impact 6: Underwater Noise and Disturbance from Construction Vessels						
PTS from Cumulative SEL	Harbour porpoise, grey seal and harbour seal	High	Negligible	Minor adverse	No mitigation required	**Minor adverse**
TTS from Cumulative SEL	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Possible behavioural response	Harbour porpoise	Low	Negligible	Negligible		**Negligible**
Impact 7: Barrier Effects from Underwater Noise						
Disturbance	Harbour porpoise	Medium	Negligible	Minor adverse	MMMP and SIP for SNS SAC	**Minor adverse**
	Grey seal and harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Impact 8: Vessel Interaction (Collision Risk) During Construction						
Increased collision risk	Harbour porpoise	Low	Low	Minor adverse	No further mitigation proposed other than good practice	**Minor adverse**
	Grey seal	Low	Low	Minor adverse		**Minor adverse**
	Harbour seal	Low	Negligible	Negligible		**Negligible**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measure	Residual Impact
Impact 9: Changes to Prey Resource						
Displacement	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor adverse	No further mitigation currently required, beyond embedded mitigation to reduce piling noise impacts	**Negligible** to **Minor adverse**
	Grey seal and harbour seal	Low	Negligible	Negligible		**Negligible**
Operation						
Impact 1: Behavioural Impacts Resulting from the Underwater Noise from Operational Wind Turbines						
PTS from Cumulative SEL	Harbour porpoise, grey seal and harbour seal	High	Negligible	Minor adverse	No mitigation required or proposed	**Minor adverse**
TTS from Cumulative SEL	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Possible behavioural response	Harbour porpoise	Low	Negligible	Negligible		**Negligible**
Impact 2: Behavioural Impacts Resulting from the Underwater Noise from Maintenance Activities						
Disturbance	Harbour porpoise, grey seal and harbour seal	Medium	Negligible	Negligible to minor adverse	No mitigation required	**Negligible to minor adverse**

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measure	Residual Impact
Impact 3: Vessel Underwater Noise and Disturbance during Operation and Maintenance						
Disturbance	Harbour porpoise, grey seal and harbour seal	Low	Negligible	Negligible	No mitigation required	**Negligible**
Impact 4: Vessel Interaction (Collision Risk) during Operation and Maintenance						
Increased collision risk	Harbour porpoise	Low	Negligible	Negligible	No further mitigation proposed other than good practice	**Negligible**
	Grey seal	Low	Negligible	Negligible		**Negligible**
	Harbour seal	Low	Negligible	Negligible		**Negligible**
Impact 5: Changes to Prey Resource during Operation and Maintenance						
Displacement	Harbour porpoise	Low to Medium	Negligible	Negligible to Minor	No further mitigation proposed	**Negligible to Minor adverse**
	Grey seal and harbour seal	Low	Negligible	Negligible		**Negligible**
Decommissioning = the same or less than assessed for construction						

Table 11.81 Summary of Potential Cumulative Impacts for Marine Mammals During Construction of the Proposed East Anglia ONE North Project

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measures	Residual Impact
Cumulative						
Impact 1: Underwater Noise During Construction from Offshore Windfarm Piling						
Disturbance during single pile installation at four offshore windfarms including East Anglia ONE North	Harbour porpoise	Medium	Low	Minor adverse	No further mitigation currently proposed	**Minor adverse**
	Grey seal	Medium	Low	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Impact 2: Underwater Noise from All Other Noise Sources						
Disturbance from non-piling noise sources	Harbour porpoise	Medium	Low	Minor adverse	No further mitigation currently proposed	**Minor adverse**
	Grey seal	Medium	Low	Minor adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Impact 1 and 2 combined: Underwater Noise from All Noise Sources including Piling						
Disturbance from all possible noise sources during construction and piling at East Anglia TWO	Harbour porpoise	Medium	Low	Minor adverse	MMMP and SIP	**Minor adverse**
	Grey seal	Medium	Medium	Moderate adverse		**Minor adverse**
	Harbour seal	Medium	Negligible	Minor adverse		**Minor adverse**
Impact 3: Changes to Prey Resources						
Displacement	Harbour porpoise, grey seal and harbour seal	No additional cumulative impacts to those assessed for disturbance from underwater noise.				

Potential Impact	Receptor	Sensitivity	Magnitude	Significance	Example of Potential Mitigation Measures	Residual Impact
Impact 4: Vessel Interaction (Collision Risk)						
Increased collision risk from vessels during offshore windfarm construction	Harbour porpoise	Low	Medium	Minor adverse	No further mitigation proposed other than good practice	**Minor adverse**
	Grey seal	Low	Medium	Minor adverse		**Minor adverse**
	Harbour seal	Low	Low	Minor adverse		**Minor adverse**

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