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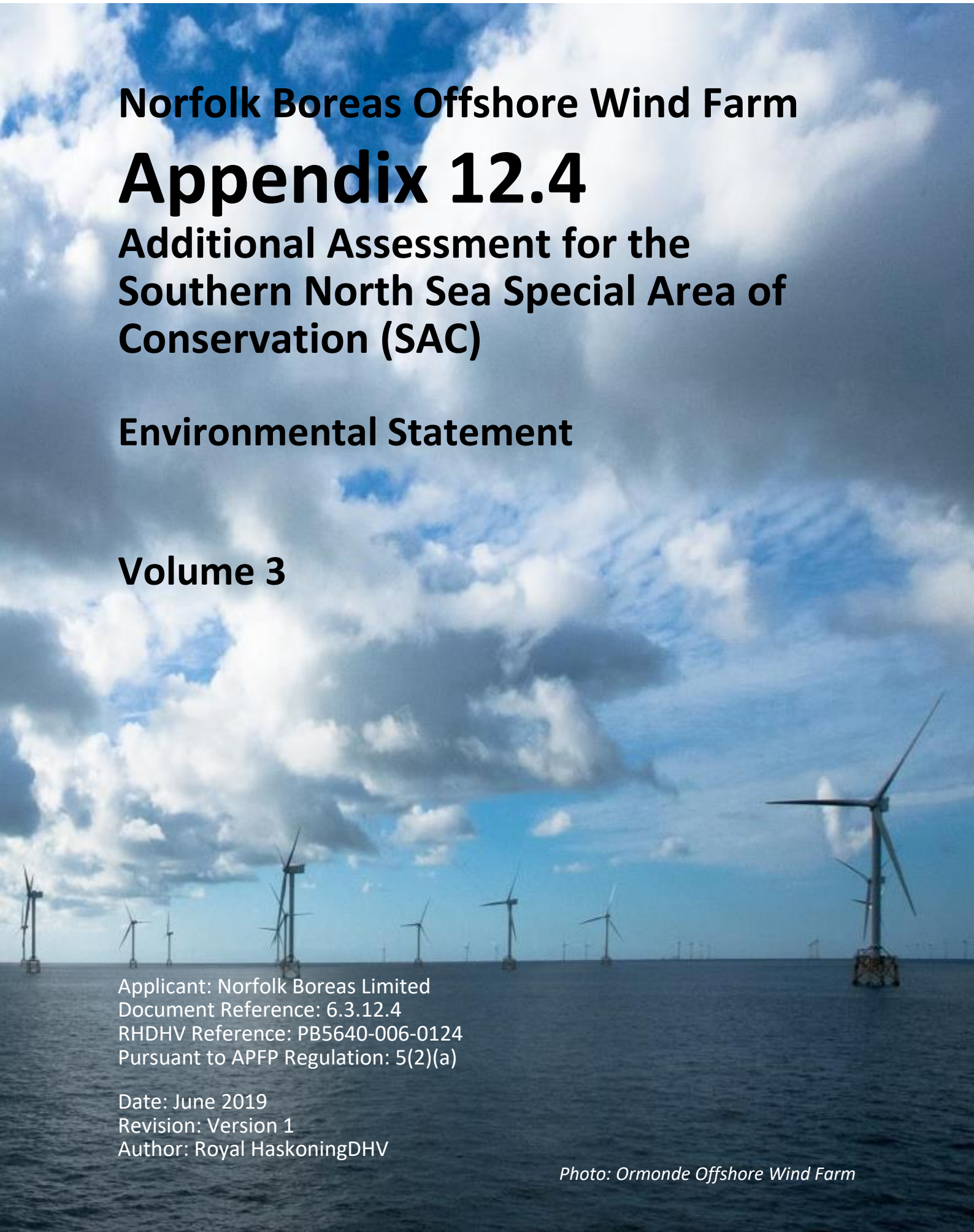
Norfolk Boreas Offshore Wind Farm

Appendix 12.4

Additional Assessment for the Southern North Sea Special Area of Conservation (SAC)

Environmental Statement

Volume 3



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Glossary of Acronyms

ADD	Acoustic Deterrent Devices
CI	Confidence Interval
CIA	Cumulative Impact Assessment
CV	Coefficient of Variation
CI	Confidence Interval
CIA	Cumulative Impact Assessment
dB	Decibel
EPS	European Protected Species
ETG	Expert Topic Group
HRA	Habitats Regulations Assessment
JNCC	Joint Nature and Conservation Committee
kg	Kilogram
kJ	Kilojoule
km	Kilometre
km^2	Kilometre squared
m	Metre
m/s	Metres per second
MMMP	Marine Mammal Mitigation Plan
MU	Management Unit
NMFS	National Marine Fisheries Service
OWFs	Offshore Wind Farms
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SCANS	Small Cetaceans in the European Atlantic and North Sea
SIP	Site Integrity Plan
SNCBs	Statutory Nature Conservation Bodies
SNS	Southern North Sea
SPL	Sound Pressure Level
TSHD	trailing suction hopper dredger
TTS	Temporary Threshold Shift
UXO	Unexploded Ordance

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support HRA.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Landfall	Where the offshore cables come ashore at Happisburgh South.
Norfolk Boreas site	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the wind farm array.
Norfolk Vanguard	Norfolk Vanguard offshore wind farm, sister project of Norfolk Boreas.
Norfolk Vanguard OWF sites	Term used exclusively to refer to the two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West (also termed NV East and

	NV West) which will contain the Norfolk Vanguard arrays.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore export cables	The cables which transmit electricity from the offshore electrical platform to the landfall.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Offshore service platform	A platform to house workers offshore and/or provide helicopter refuelling facilities. An accommodation vessel may be used as an alternative for housing workers.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard sites.
Project interconnector search area	The area within which project interconnector cables would be installed.
Safety zone	An area around a vessel which should be avoided during offshore construction.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Boreas Limited.
The project	Norfolk Boreas Wind Farm including the onshore and offshore infrastructure.

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1 Introduction

1.1 Purpose of this Document

1. The purpose of this Appendix is to provide an assessment of effects on the estimated population of harbour porpoise that could be present in the Southern North Sea SAC. This approach was agreed with the marine mammals Expert Topic Group for the Norfolk Vanguard Evidence Plan Process meeting on the 15th February 2017.

2. Therefore, for information purposes, this Appendix presents an assessment on the estimated number of harbour porpoise that the SNS SAC site could support of 29,384 harbour porpoise. This estimate is based on the UK North Sea MU area (322,897km^2), the overall harbour porpoise density estimate of 0.52/km^2 (Coefficient of Variation (CV) = 0.18) for the North Sea MU area from the SCANS-III survey (Hammond et al., 2017) and the estimated UK North Sea MU population of 167,906 harbour porpoise, with 17.5% of the population within the UK part of the North Sea MU of approximately **29,384 harbour porpoise**.

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

4. The SNS SAC has been recognised as an area with persistent high densities of harbour porpoise (Joint Nature and Conservation Committee (JNCC), 2017a). The SNS SAC has a surface area of 36,715km^2 and covers both winter and summer habitats of importance to harbour porpoise, with approximately 66% of the candidate site being important in the summer and the remaining 33% of the site being important in the winter period (JNCC, 2017a). Norfolk Boreas lies wholly within the SNS SAC (see Figure 12.1 of the Environmental Statement (ES) and is located wholly within the summer area.

5. The SNS cSAC Site Selection Report (JNCC, 2017a) identifies that the SNS SAC site supports approximately 18,500 individuals (95% Confidence Interval (CI) = 11,864 - 28,889) for at least part of the year (JNCC, 2017a). However, JNCC (2017a) states that because this estimate is from a one-month survey in a single year the Small Cetaceans in the European Atlantic and North Sea (SCANS) II survey in July 2005 (Hammond et al., 2013) it cannot be considered as an estimated population for the site. It is therefore not appropriate to use site population estimates in any assessments of effects of plans or projects, as these need to take into consideration population estimates at the Management Unit (MU) level, to account for daily and seasonal movements of the animals (JNCC, 2017a).

6. The North Sea MU population of 345,373 (CV = 0.18; 95% CI = 246,526-495,752; Hammond et al., 2017) based on the SCANS-III data, has been used as the reference population throughout the assessment in the ES. As agreed with the marine mammal Expert Topic Group (ETG) as part of the Evidence Plan Process (EPP).

7. However, it was also agreed with the ETG at the meeting on 15th February 2017 for both Norfolk Vanguard and Norfolk Boreas that the estimate that the SNS SAC could support 17.5% of the UK North Sea reference population would be assessed in a separate appendix for information, as provided here.

2 Potential Impacts during Construction

2.1 Impact 1: Underwater Unexploded Ordnance clearance

8. Caution should also be raised over the longer range Sound Pressure Level $(SPL)_{peak}$ values. Peak noise levels are difficult to predict accurately in a shallow water environment (von Benda Beckmann, 2015) and would tend to be significantly over-estimated over ranges of the order of 3km compared to real data (Appendix 5.5). Therefere, as a precautionary approach, it is considered that the maximum potential impact range for PTS is likely to be 5km.

9. An Unexploded Ordance (UXO) clearance Marine Mammal Mitigation Plan (MMMP) will be produced post-consent in consultation with the relevant Statutory Nature Conservation Bodies (SNCBs) and will be based on the latest scientific understanding and guidance, pre-construction UXO surveys in the Norfolk Boreas offshore project area, and detailed project design. The MMMP will detail the proposed mitigation measures to reduce the risk of any lethal injury, physical injury or permanent auditory injury (Permanent Threshold Shift (PTS)) to harbour porpoise during any underwater detonations.

Table 2.1 Potential impact of permanent auditory injury (PTS) on harbour porpoise during UXO clearance without mitigation

Potential Impact	TNT Equivalent / Charge weights	25kg	60kg	145kg	151kg	312kg	340kg	770kg
	Source Level, SPL_{PEAK}	284.9 dB	287.7 dB	290.6 dB	290.7 dB	293.1 dB	293.4 dB	296.1 dB
PTS SPL_{peak} Unweighted (National Marine Fisheries Service (NMFS), 2018)	202 dB re 1 µPa	4.6km	6.1km	8.3km	8.4km	10.7km	11.0km	14.4km
PTS SEL Weighted (NMFS, 2018)	155 dB re 1 μPa^2s	0.56km	0.76km	1.0km	1.0km	1.2km	1.2km	1.5km

Potential Impact	TNT Equivalent / Charge weights	25kg	60kg	145kg	151kg	312kg	340kg	770kg
	SOURCE LEVEL, SPL_{PEAK}	284.9 dB	287.7 dB	290.6 dB	290.7 dB	293.1 dB	293.4 dB	296.1 dB
Number of harbour porpoise and % of reference population[1] based on maximum impact range (14.4km) for PTS unweighted SPL_{peak} (NMFS, 2018)	Maximum impact area* based on unweighted SPL_{peak} = 651.44km^2 578 harbour porpoise (0.17% of NS MU; 2.0% of SNS SAC) based on SCANS-III survey density (0.888/km^2). 691 harbour porpoise (0.2% of NS MU; 2.4% of SNS SAC) based on the site specific survey density at the Norfolk Boreas site (1.06/km^2).							
Number of harbour porpoise and % of reference population[1] based on maximum impact range (5km) for PTS	Maximum impact area* based on 5km range = 78.5km^2 70 harbour porpoise (0.02% of NS MU; 0.24% of SNS SAC) based on SCANS-III survey density (0.888/km^2). 83 harbour porpoise (0.02% of NS MU; 0.28% of SNS SAC) based on the site specific survey density at the Norfolk Boreas site (1.06/km^2).							

*Maximum area based on area of circle with maximum impact range for radius.

Table 2.2 Potential maximum impact of temporary auditory injury (Temporary Threshold Shift (TTS)) and fleeing response on harbour porpoise during UXO clearance

Potential Impact	TNT Equivalent / Charge weights	25kg	60kg	145kg	151kg	312kg	340kg	770kg
	SOURCE LEVEL, SPL_{PEAK}	284.9 dB	287.7 dB	290.6 dB	290.7 dB	293.1 dB	293.4 dB	296.1 dB
TTS SPL_{peak} Unweighted (NMFS, 2018)	196 dB re 1 µPa	8.5km	11.3km	15.2km	15.4km	19.6km	20.2km	26.5km
TTS SEL Weighted (NMFS, 2018)	140 dB re 1 µPa^{2}s	2.4km	2.8km	3.3km	3.3km	3.7km	3.7km	4.2km
Number of harbour porpoise and % of reference population[1] based on maximum impact range (26.5km) for TTS SPL_{peak} unweighted (NMFS, 2018)	Maximum impact area* based on weighted TTS SEL = 2,206.2km^2 1,959 harbour porpoise (0.6% of NS MU; 6.7% of SNS SAC) based on SCANS-III survey density (0.888/km^2). 2,339 harbour porpoise (0.7% of NS MU; 8.0% of SNS SAC) based on the site specific survey density at the Norfolk Boreas site (1.06/km^2).							

*Maximum area based on area of circle with maximum impact range for radius.

10. The number of harbour porpoise that could potentially be at risk of TTS or disturbance has been estimated without mitigation. The proposed mitigation to

reduce the risk of PTS would ensure that harbour porpoise 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 or disturbance would also be reduced.

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

Table 2.3 Estimated number of harbour porpoise potentially disturbed during UXO clearance

Potential Impact	Estimated number in impact area	% of reference population
Area of disturbance (2,124km^2) during underwater UXO clearance	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,251 harbour porpoise based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	0.55% of NS MU (6.4% SNS SAC) based on SCANS-III density. 0.65% of NS MU (7.7% SNS SAC) based on the site specific survey density of Norfolk Boreas.

12. The spatial assessment of the potential effects of disturbance during UXO clearance on the SNS SAC will be assessed in the information for the Habitats Regulation Assessment (HRA).

2.2 Impact 2: Underwater noise during piling

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

14. In addition to the MMMP, a Norfolk Boreas Southern North Sea SAC Site Integrity Plan (SIP) will be developed, if required. The SIP will set out the approach to deliver any project mitigation or management measures in relation to the SAC.

15. A draft MMMP (document reference 8.13) and an In principle SIP (document reference 8.17) have been submitted with this DCO application.

Table 2.4 Maximum number of individuals (and % of reference population) that could be at risk of permanent auditory injury (PTS) from a single strike and from cumulative exposure

Potential Impact	Criteria and threshold	Monopile with maximum hammer energy of 5,000kJ	Pin-pile with maximum hammer energy of 2,700kJ	Starting hammer energy of 500kJ
		Maximum number of individuals (% of reference population) with no mitigation.		
PTS without mitigation – single strike	NMFS (2018) unweighted SPL_{peak} 202 dB re 1 µPa	0.33 harbour porpoise (0.0001% NS MU; 0.001% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 0.40 harbour porpoise (0.0001% NS MU; 0.001% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	0.18 harbour porpoise (0.00005% NS MU; 0.0006% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 0.22 harbour porpoise (0.00006% NS MU; 0.0007% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	0.012 harbour porpoise (0.000004% NS MU; 0.00004% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 0.015 harbour porpoise (0.000004% NS MU; 0.00005% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.
PTS – cumulative exposure (including soft-start and ramp-up)	NMFS (2018) SEL_{cum} Weighted 155 dB re 1 µPa^{2}s	0.028 harbour porpoise (0.000008% NS MU; 0.0001% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 0.033 harbour porpoise (0.00001% NS MU; 0.0001% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	0.18 harbour porpoise (0.00005% NS MU; 0.0006% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 0.2 harbour porpoise (0.00006% NS MU; 0.0007% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	N/A

Table 2.5 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 from cumulative exposure

Potential Impact	Criteria and threshold	Maximum number of individuals (% of reference population)	
		Monopile with maximum hammer energy of 5,000kJ	Pin-pile with maximum hammer energy of 2,700kJ
TTS / fleeing response – single strike	NMFS (2018) unweighted SPL_{peak} 196 dB re 1 µPa	1.8 harbour porpoise (0.0005% NS MU; 0.006% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 2.1 harbour porpoise (0.0006% NS MU; 0.007% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	0.9 harbour porpoise (0.0003% NS MU; 0.003% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 1.1 harbour porpoise (0.0003% NS MU; 0.003% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.
TTS / fleeing response without mitigation – cumulative exposure	NMFS (2018) SEL_{cum} Weighted 140 dB re 1 µPa^{2}s	136 harbour porpoise (0.04% NS MU; 0.5% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 162 harbour porpoise (0.05% NS MU; 0.55% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	512 harbour porpoise (0.15% NS MU; 1.7% SNS SAC) based on SCANS-III survey block O density (0.888/km^2). 611 harbour porpoise (0.18% NS MU; 2.1% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.

Table 2.6 Estimated number of harbour porpoise potentially disturbed during piling based on 26km range from piling location

Potential Impact	Estimated number in impact area	% of reference population
Area of disturbance (2,124km^2) from underwater noise during piling	1,886 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,251 harbour porpoise based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	0.55% of NS MU (6.4% SNS SAC) based on SCANS-III density. 0.65% of NS MU (7.7% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.
Two concurrent piling events in the Norfolk Boreas site (4,147km^2)	3,682.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,396 harbour porpoise based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.	1.1% NS MU (12.5% SNS SAC) based on SCANS-III density. 1.3% of NS MU (15.0% SNS SAC) based on site specific survey density (1.06/km^2) at the Norfolk Boreas site.

Table 2.7 Estimated number of harbour porpoise that could exhibit a possible behavioural response to underwater noise during piling

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
Possible behavioural response to underwater noise during piling – maximum hammer energy for monopile (1,543km^2)	1,370 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 1,636 harbour porpoise based on site specific survey density (1.06/km^2) at Norfolk Boreas.	0.4% of NS MU (4.7% SNS SAC) based on SCANS-III density. 0.47% of NS MU (5.7% SNS SAC) based on site specific survey density at Norfolk Boreas.	1,028 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 1,227 harbour porpoise based on site specific survey density (1.06/km^2) at Norfolk Boreas.	0.3% of NS MU (3.5% SNS SAC) based on SCANS-III density. 0.36% of NS MU (4.2% SNS SAC) based on site specific survey density at Norfolk Boreas.	685 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 818 harbour porpoise based on site specific survey density (1.06/km^2) at Norfolk Boreas.	0.2% of NS MU (2.3% SNS SAC) based on SCANS-III density. 0.24% of NS MU (2.8% SNS SAC) based on site specific survey density at Norfolk Boreas.
Possible behavioural response to underwater noise during piling – maximum hammer energy for pin-pile (1,144km^2)	1,016 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 1,213 harbour porpoise based on site specific survey density (1.06/km^2) at Norfolk Boreas.	0.3% of NS MU (3.5% SNS SAC) based on SCANS-III density. 0.35% of NS MU (4.1% SNS SAC) based on site specific survey density at Norfolk Boreas.	762 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 910 harbour porpoise based on site specific survey density (1.06/km^2) at Norfolk Boreas.	0.22% of NS MU (2.6% SNS SAC) based on SCANS-III density. 0.26% of NS MU (3.1% SNS SAC) based on site specific survey density at Norfolk Boreas.	508 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 607 harbour porpoise based on site specific survey density (1.06/km^2) at Norfolk Boreas.	0.15% of NS MU (1.7% SNS SAC) based on SCANS-III density. 0.18% of NS MU (2.1% SNS SAC) based on site specific survey density at Norfolk Boreas.

2.3 Impact 3: Underwater noise during other construction activities

16. 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 Norfolk Boreas site (see Appendix 5.3 for further information). The activities that were assessed include:

- Dredging (estimated sound source of 186dB re 1µPs @1m): a trailing suction hopper dredger (TSHD) may be required for the export cable, array cable and interconnector 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.

17. 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 500m for some activities and less than 50m for most) 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 2.8 Maximum number of individuals (and % of reference population) that could be at risk of impacted from as a result of underwater noise associated with other construction activities, other than piling, based on underwater noise modelling

Potential Impact (area km^2)	Criteria and Threshold	Estimated number in impact area	% of reference population
Dredging (0.07km^2)	NMFS (2018) 155 dB re 1 µPa PTS from cumulative SEL	0.06 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 0.07 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km^2).	0.00002% of NS MU (0.0002% SNS SAC) based on SCANS-III density. 0.00002% of NS MU (0.0002% SNS SAC) based on site specific survey density.
	Lucke et al. (2009) Unweighted SEL_{ss} 145 dB re 1 µPa Possible behavioural response	0.06 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 0.07 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km^2).	0.00002% of NS MU (0.0002% SNS SAC) based on SCANS-III density. 0.00002% of NS MU (0.0002% SNS SAC) based on site specific survey density.
Drilling (0.03km^2)	NMFS (2018) 155 dB re 1 µPa PTS from	0.03 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 0.03 harbour porpoise based on the	0.000009% of NS MU (0.0001% SNS SAC) based on SCANS-III density.

Potential Impact (area km²)	Criteria and Threshold	Estimated number in impact area	% of reference population
	cumulative SEL	Norfolk Boreas site specific survey density (1.06/km²).	0.000009% of NS MU (0.0001% SNS SAC) based on site specific survey density.
Drilling (0.05km²)	Lucke et al. (2009) Unweighted SEL_{ss} 145 dB re 1 µPa Possible behavioural response	0.04 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 0.05 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.00001% of NS MU (0.0001% SNS SAC) based on SCANS-III density. 0.000015% of NS MU (0.0002% SNS SAC) based on site specific survey density.
Cable laying (0.03km²)	NMFS (2018) 155 dB re 1 µPa PTS from cumulative SEL	0.03 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 0.03 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.000009% of NS MU (0.0001% SNS SAC) based on SCANS-III density. 0.000009% of NS MU (0.0001% SNS SAC) based on site specific survey density.
Cable laying (0.04km²)	Lucke et al. (2009) Unweighted SEL_{ss} 145 dB re 1 µPa Possible behavioural response	0.04 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 0.04 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.00001% of NS MU (0.0001% SNS SAC) based on SCANS-III density. 0.00001% of NS MU (0.0001% SNS SAC) based on site specific survey density.
Rock placement (0.66km²)	NMFS (2018) 155 dB re 1 µPa PTS from cumulative SEL	0.6 harbour porpoise based on SCANS-III survey block O density. 0.7 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.0002% of NS MU (0.002% SNS SAC) based on SCANS-III density. 0.0002% of NS MU (0.002% SNS SAC) based on site specific survey density.
Rock placement (0.1km²)	Lucke et al. (2009) Unweighted SEL_{ss} 145 dB re 1 µPa Possible behavioural response	0.09 harbour porpoise based on SCANS-III survey block O density. 0.1 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.00003% of NS MU (0.0003% SNS SAC) based on SCANS-III density. 0.00003% of NS MU (0.0003% SNS SAC) based on site specific survey density.
Trenching (0.03km²)	NMFS (2018) 155 dB re 1 µPa PTS from cumulative SEL	0.03 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 0.03 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.000009% of NS MU (0.0001% SNS SAC) based on SCANS-III density. 0.000009% of NS MU (0.0001% SNS SAC) based on site specific survey density.
Trenching (0.04km²)	Lucke et al. (2009) Unweighted SEL_{ss} 145 dB re 1 µPa Possible	0.04 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 0.04 harbour porpoise based on the Norfolk Boreas site specific survey	0.00001% of NS MU (0.0001% SNS SAC) based on SCANS-III density. 0.00001% of NS MU (0.0001%

Potential Impact (area km²)	Criteria and Threshold	Estimated number in impact area	% of reference population
	behavioural response	density (1.06/km²).	SNS SAC) based on site specific survey density.

2.4 Impact 4: Vessel underwater noise and disturbance

18. The maximum number of vessels on site at any one time during construction is estimated to be 57 vessels.

19. Underwater noise generated by vessels would only be sufficient to cause PTS, other injury or TTS to harbour porpoise if the individual remained within 150m of the vessel for a period of 24 hours, which is highly unlikely. Disturbance is therefore the only potential underwater noise effect associated with vessels.

20. 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 Norfolk Boreas site (see Appendix 5.3 for further information). The sound sources for vessels modelled were 171dB re 1µPs @1m for large vessels and 164dB re 1µPs @1m for medium vessels.

21. 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 150m) of the vessel for 24 hours to be exposed to levels of sound that are sufficient to induce PTS as per the NMFS (2018) threshold criteria.

Table 2.9 Maximum number of individuals (and % of reference population) that could be impacted as a result of underwater noise associated with vessels

Potential Impact (area km²)	Criteria and Threshold	Estimated number in impact area	% of reference population[1]
Large vessels (57 x 0.03km²)	NMFS (2018) 155 dB re 1 µPa PTS from cumulative SEL	1.5 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 1.8 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.0004% of NS MU (0.005% SNS SAC) based on SCANS-III density. 0.0005% of NS MU (0.006% SNS SAC) based on site specific survey density.
Large vessels (57 x 0.07km²)	Lucke et al. (2009) Unweighted SELss 145 dB re 1 µPa Possible behavioural response	3.6 harbour porpoise based on SCANS-III survey block O density (0.888/km²). 4.2 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km²).	0.001% of NS MU (0.01% SNS SAC) based on SCANS-III density. 0.001% of NS MU (0.01% SNS SAC) based on site specific survey density.

2.5 Impact 5: Barrier effects from underwater noise

22. The spatial worst-case is the maximum area (4,147km^2) over which potential disturbance could occur at any one time based on two concurrent foundations being installed (Table 2.6). However, this would only be a relatively small duration of the potential construction period.

23. The duration of concurrent piling, for two concurrent locations would be approximately half the total maximum duration for single pile installation, as well as reducing the overall construction window. The maximum concurrent piling duration (including ADD activation) for Norfolk Boreas would be up to 647 hours 48 minutes (equivalent of up to approximately 27 days).

24. For the single phase approach, this would be approximately 5% of the 18 month (547 days) foundation installation period and 2.5% of the 36 month (1,096 day) overall construction period.

25. For the two phase approach, this would be approximately 14 days per phase, and therefore 5% of each of the two nine month (274 day) foundation installation periods and 1.2% of the 39 month (1,094 day) overall construction period.

26. It is important to note that piling, and therefore any potential barrier effects, would not be constant during the construction periods and phases of development. It is therefore important to take into account when piling is not taking place, there are periods where harbour porpoise could return to the area, rather than assuming that they will be disturbed / move away for the construction period, especially when assessing the potential temporal impacts and any barrier effects.

2.5 Impact 6: Vessel collision risk

27. As a precautionary worse-case scenario approach, the number of harbour porpoise that could be at increased collision with vessels during construction has been assessed based on 5-10% of the number of animals that could be present in the wind farm areas and the offshore cable corridor,being at potential increased collision risk.

28. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Boreas offshore project area would be at increased collision risk with vessels during construction, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

Table 2.10 Estimated number of harbour porpoise that could be present in the Norfolk Boreas offshore area at potential increased collision risk based on 95-90% avoidance

Potential Impact Area	Estimated number at potential increased collision risk based on 95-90% avoidance	% of reference population[1]
Total offshore project area (1,178km^2)	52-104 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 62-125 harbour porpoise based on site specific survey density (1.06/km^2).	0.015-0.03% of NS MU (0.2-0.4% SNS SAC) based on SCANS-III density. 0.02-0.04% of NS MU (0.2-0.4% SNS SAC) based on site specific survey density.

2.6 Impact 7: Changes to prey resource

29. As a precautionary worse-case scenario, the number of harbour porpoise 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 Norfolk Boreas offshore project area This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor. It is more likely that effects would be restricted to an area around the working sites.

30. In addition, there would be no additional displacement of harbour porpoise as a result of any changes in prey resources during construction, as harbour porpoise would be potentially disturbed from the wind farm sites or cable corridor as a result of underwater noise during piling, other construction activities or vessels, as the potential area of effect would be less or the same as those assessed for piling, other construction activities or vessels.

Table 2.11 Estimated number of harbour porpoise that could be present in the Norfolk Boreas offshore project area (wind farm site, project interconnector cable search areas and cable corridor)

Potential Impact Area	Estimated number in impact area[1]	% of reference population[1]
Total offshore project area (1,178km^2)	1,046 harbour porpoise based on SCANS-III survey block O density. 1,249 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km^2).	0.3% of NS MU (3.6% SNS SAC) based on SCANS-III density. 0.4% of NS MU (4.3% SNS SAC) based on site specific survey density.

3 Potential Impacts during Operation

31. Once commissioned, the wind farm would have a design life of approximately 30 years. All offshore infrastructure including wind turbines, foundations, cables and offshore substations would be monitored and maintained during this period in order to maximise efficiency.

3.1 Impact 8: Underwater noise from operational turbines

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

33. To predict the operational noise levels at Norfolk Boreas, the noise levels of existing operational turbines were taken and used to predict the noise levels for Norfolk Boreas based on the size of the turbines (see Appendix 5.4 for more information). The sound source for operational turbines modelled was 165.4dB re 1µP (RMS) @1m for 20MW turbines.

34. The results of the underwater noise modelling indicates that at the source levels predicted for operational underwater noise, any marine mammal would have to remain in close proximity (i.e. less than 110m) of the turbine for 24 hours to be exposed to levels of sound that are sufficient to induce PTS as per the NMFS (2018) threshold criteria.

Table 3.1 Maximum number of individuals (and % of reference population) that could be impacted as result of underwater noise associated with operational turbines

Potential Impact (area km^2)	Criteria and Threshold	Estimated number in impact area[1]	% of reference population[1]
20MW turbine (0.03km^2) x 90	NMFS (2018) 155 dB re 1 µPa PTS from cumulative SEL	2.4 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2.7 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km^2).	0.0007% of NS MU (0.008% SNS SAC) based on SCANS-III density. 0.0008% of NS MU (0.009% SNS SAC) based on site specific survey density.
20MW turbine (0.04km^2) x 90	Lucke et al. (2009) Unweighted SEL_{ss} 145 dB re 1 µPa Possible behavioural response	3.2 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 3.8 harbour porpoise based on the Norfolk Boreas site specific survey density (1.06/km^2).	0.0009% of NS MU (0.01% SNS SAC) based on SCANS-III density. 0.001% of NS MU (0.01% SNS SAC) based on site specific survey density.

3.2 Impact 9: Underwater noise from maintenance activities

35. 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.

36. As a precautionary worse-case scenario approach, the number of harbour porpoise that could be disturbed as a result of underwater noise from activities during the construction phase, other than piling, is also used for the assessment during the operation and maintenance phase (Table 2.8 Maximum number of individuals (and % of reference population) that could be at risk of impacted from as a result of underwater noise associated with other construction activities, other than piling, based on underwater noise modelling).

37. This is very precautionary, as it is highly unlikely that maintenance activities could result in disturbance to the same level as during the construction phase.

3.3 Impact 10: Vessel underwater noise and disturbance during operation and maintenance

38. Taking into account the existing vessel movements in around the Norfolk Boreas area and the potential 1-2 vessel movement 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. Therefore, there is no increase in the potential for disturbance to harbour porpoise as a result of the increased number of vessels during operation and maintenance at Norfolk Boreas.

39. The potential impacts as a result of underwater noise and disturbance from additional vessels during operation and maintenance from vessels would be short-term and temporary in nature. Disturbance responses are likely to be limited to the area in the immediate vicinity of the vessel. Harbour porpoise would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

40. As a precautionary worse-case scenario approach, the number of harbour porpoise that could be disturbed as a result of vessl noise during the construction phase is also used for the assessment during the operation and maintenance phase (Table 2.9).

41. This is very precautionary, as it is highly unlikely that vessel noise could result in disturbance to the same level as during the construction phase.

3.4 Impact 11: Vessel collision risk

42. Based on the worst-case scenario of an average of two vessel movements per day, the increase in vessels movement per day at the Norfolk Boreas site (up to approximately 445 round trips per year) during operation and maintenance is relatively small compared to existing vessel traffic.

43. As a precautionary worst-case scenario approach the number of harbour porpoise that could be at increased collision with vessels during operation and maintenance

has been assessed based on the number of animals that could be present in the Norfolk Boreas offshore project area and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 2.10).

44. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Boreas offshore project area would be at increased collision risk with vessels during operation and maintenance, especially taking into account the relatively small increase in number of vessel movements compared to existing vessel movements in the area.

3.5 Impact 12: Changes to prey resource during operation and maintenance

45. Based on the worst-case scenario for the total footprint (presence of wind turbine and platform foundations, scour protection, array cables, inter-connector cables, and cable protection; 6.4km^2), approximately 7 harbour porpoise (0.002% of the North Sea MU reference population; 0.02% of SNS SAC) could potentially be impacted by any changes to prey resources.

4 Potential Impacts during Decommissioning

46. Possible effects on harbour porpoise associated with the decommissioning stage(s) have been assessed; however, a further assessment will be carried out ahead of any decommissioning works to be undertaken taking account of known information at that time, including relevant guidelines and requirements.

4.1 Impact 13: Underwater noise from foundation removal

47. A detailed decommissioning plan will be provided prior to decommissioning that will give details of the techniques to be employed and any relevant mitigation measures.

48. For this assessment, it is assumed that the potential impacts from underwater noise during decommissioning would be less than those assessed for piling and comparable to those assessed for other construction activities.

4.2 Impact 14: Barrier effects from underwater noise

49. For this assessment, it is assumed that the potential impacts any barrier effects during decommissioning would be less than those assessed for construction.

4.3 Impact 15: Vessel underwater noise and disturbance from vessels

50. For this assessment, it is assumed that the potential impacts would be the same as for construction.

4.4 Impact 16: Vessel collision risk

51. For this assessment, it is assumed that the potential impacts would be the same as for construction.

4.5 Impact 17: Changes to prey resource

52. For this assessment, it is assumed that the potential impacts would be the same as for construction.

5 Cumulative Impacts

5.1 Approach

53. The approach to this cumulative assessment differs from that taken in the ES chapter in terms of geographic range. If this assessment is based upon the number of harbour porpoise that the SNS SAC could potentially support, then it follows that impacts must be limited to those occurring within the SNS SAC boundary, if impacts outside the boundary are included (as per the ES) then the population used for the assessment must reflect that (i.e. the North Sea MU population as per the ES).

5.2 Impact 1: Underwater noise impacts during construction from offshore wind farm piling

54. Auditory injury (PTS) could occur as a result of pile driving during offshore wind farm installation, pile driving during oil and gas platform installation, underwater explosives (used occasionally during the removal of underwater structures and UXO clearance) and seismic surveys (JNCC, 2010a, 2010b, 2017b). However, if there is the potential for any auditory injury (PTS) suitable mitigation would be put in place to reduce any risk to harbour porpoise.

55. Other activities such as dredging, drilling, rock dumping and disposal, vessel activity, operational wind farms, oil and gas installations or wave and tidal sites will emit broadband noise in lower frequencies and auditory injury (PTS) from these activities is very unlikely. Therefore, the potential risk of any auditory injury (PTS) in harbour porpoise is not included in the Cumulative Impact Assessment (CIA).

56. Following the current advice from the SNCBs, the CIA has been based on the following parameters:

- A distance of 26km from an individual percussive piling location has been used to assess the area that harbour porpoise 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 could potentially be disturbed.
- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise could potentially be disturbed.

57. 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.

58. The potential disturbance from offshore wind farms during construction activities other than pile driving noise sources, including vessels, seabed preparation, rock dumping and cable installation, has been based on the area of the offshore wind

farm sites, this is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity and other noisy activities including the operation of large vessels, rock dumping or cable burial would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

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

60. 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.

61. The conservative potential worst-case scenario for offshore wind farms that could be piling at the same time as Norfolk Boreas in the SNS SAC includes four other UK offshore wind farms:

- Creyke Beck A;
- Teeside A;
- Hornsea Project 3; and
- East Anglia ONE North.

62. In this likely worst-case scenario, for concurrent piling, the estimated maximum area of potential disturbance is 21,240km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms.

63. Based on a single pile installation at each of the five offshore wind farms (including Norfolk Boreas), the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms.

64. In this assessment (which is different from the ES) the number of harbour porpoise that could be disturbed has been estimated based on the potential area of overlap with the SNS SAC (Table 5.1). The number of harbour porpoise has been estimated using the SCANS-III density estimate for survey block O of 0.888 harbour porpoise per km^2 as a worst-case scenario (as there are currently no available density estimates for the winter and summer SNS SACs areas that are suitable to use, as the data Heinänen and Skov (2015) covers the wider area).

Table 5.1 Estimated maximum, minimum and average overlap with SNS SAC winter and summer areas for potential worst-case scenarios (Dogger Bank Creyke Beck A, Dogger Bank Teeside A, Hornsea Project Three, East Anglia ONE North and Norfolk Boreas) for single and concurrent piling and the number of harbour porpoise that could be disturbed from these areas in the SNS SAC

In-combination assessment scenario	Maximum area overlap with SNS SAC	Minimum area overlap with SNS SAC	Average area overlap with SNS SAC
Potential worst-case scenario (5 offshore wind farms) – single piling	Maximum overlap with summer SNS SAC area = 5,422km^2 [4,815 harbour porpoise (1.4% NS MU; 16.4% SNS SAC)] Maximum overlap with winter SNS SAC area = 2,395km^2 [2,127 harbour porpoise (0.6% NS MU; 7.2% SNS SAC)] Total maximum overlap with SNS SAC = 6,784km^2 [6,024 harbour porpoise (1.7% NS MU; 20.5% SNS SAC)]	Minimum overlap with summer SNS SAC area = 2,493km^2 [2,214 harbour porpoise (0.6% NS MU; 7.5% SNS SAC)] Minimum overlap with winter SNS SAC area = 2,123km^2 [1,885 harbour porpoise (0.55% NS MU; 6.4% SNS SAC)] Total minimum overlap with SNS SAC = 4,362km^2 [3,873 harbour porpoise (1.1% NS MU; 13.2% SNS SAC)]	Average overlap with summer SNS SAC area = 3,958km^2 [3,515 harbour porpoise (1.0% NS MU; 12.0% SNS SAC)] Average overlap with winter SNS SAC area = 2,259km^2 [2,006 harbour porpoise (0.6% NS MU; 6.8% SNS SAC)] Total average overlap with SNS SAC = 5,573km^2 [4,949 harbour porpoise (1.4% NS MU; 16.8% SNS SAC)]
Potential worst-case scenario (5 offshore wind farms) – concurrent piling	Maximum overlap with summer SNS SAC area = 7,542km^2 [6,697 harbour porpoise (1.9% NS MU; 22.8% SNS SAC)] Maximum overlap with winter SNS SAC area = 3,421km^2 [3,038 harbour porpoise (0.9% NS MU; 10.3% SNS SAC)] Total maximum overlap with SNS SAC = 9,378km^2 [8,328 harbour porpoise (2.4% NS MU; 28.3% SNS SAC)]	Minimum overlap with summer SNS SAC area = 2,592km^2 [2,302 harbour porpoise (0.7% NS MU; 7.8% SNS SAC)] Minimum overlap with winter SNS SAC area = 2,155km^2 [1,914 harbour porpoise (0.55% NS MU; 6.5% SNS SAC)] Total minimum overlap with SNS SAC = 4,437km^2 [3,940 harbour porpoise (1.1% NS MU; 13.4% SNS SAC)]	Average overlap with summer SNS SAC area = 5,067km^2 [4,499 harbour porpoise (1.3% NS MU; 15.3% SNS SAC)] Average overlap with winter SNS SAC area = 2,788km^2 [2,476 harbour porpoise (0.7% NS MU; 8.4% SNS SAC)] Total average overlap with SNS SAC = 6,908km^2 [6,134 harbour porpoise (1.8% NS MU; 20.1% SNS SAC)]

5.3 Impact 2: Underwater noise impacts from all other noise sources

5.3.1 UXO clearance

65. The commitment to the MMMP for UXO clearance would result in no potential effects for lethal injury, physical injury and permanent auditory injury (PTS). As such, the proposed Norfolk Boreas project would not contribute to any cumulative impacts for lethal injury, physical injury and permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

66. It is currently not possible to estimate the exact number of potential UXO clearance operations that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Boreas.

67. It has therefore been assumed as a worst-case scenario that there could potentially be up to two UXO detonations at any one time:

i) both are in the summer SAC area;

ii) both are in the winter SAC area; or

iii) one is in the summer SAC area and one is in the winter SAC area.

68. Following the current SNCB advice, the CIA has been based on the following parameter:

- A distance of 26km around UXO clearance has been used to assess the area that harbour porpoise could potentially be disturbed.

69. If two UXO detonations were undertaken at the same time the potential area of disturbance could be 4,248km^2, which is approximately 15.7% of summer SAC area and 33.5% of the winter SAC area.

70. If one UXO detonation was undertaken, the potential area of disturbance could be (2,124km^2) which would be approximately 7.9% of summer SAC area and 16.7% of the winter SAC area.

71. The number of harbour porpoise has been estimated using the SCANS-III density estimate for survey block O of 0.888 harbour porpoise per km^2 as a worst-case scenario (Hammond et al., 2017).

72. However, it is highly unlikely that two UXO clearance operations would actually be undertaken at the same time in either the summer or winter area of the SNS SAC.

Table 5.2 Quantified CIA for the potential disturbance of harbour porpoise during up to two UXO clearance operations in the SNS SAC

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise impacted
One UXO clearance operation	0.888	2,124km^2	1,886 (0.6% NS MU; 6% SNS SAC)
Two UXO clearance operations	0.888	4,248km^2	3,772 (1% NS MU: 13% SNS SAC)

5.3.2 Seismic surveys

73. It is currently not possible to estimate the number of potential seismic surveys that could be undertaken in the harbour porpoise NS MU during the construction and potential piling activity at Norfolk Boreas.

74. It has therefore been assumed as a worst-case scenario that there could potentially be up to two seismic surveys at any one time:

    i) both are in the summer SAC area;

    ii) both are in the winter SAC area; or

    iii) one is in the summer SAC area and one is in the winter SAC area.

75. Following the current SNCB advice, the CIA has been based on the following parameter:

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

76. 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, 2017b). JNCC (2071b) do not, therefore, advise mitigation is required for multi-beam surveys in shallow waters as there is no risk to European Protected Species (EPS) in relation to deliberate injury or disturbance offences.

77. Therefore, for the maximum of up to two seismic surveys being undertaken at the same time the potential disturbance area would be 628km^2.

78. The number of harbour porpoise has been estimated using the SCANS-III density estimate for survey block O of 0.888 harbour porpoise per km^2 as a worst-case scenario (Hammond et al., 2017).

79. However, it is highly unlikely that up to two seismic surveys would be undertaken at the same time in either the summer or winter area of the SNS SAC.

Table 5.3 Quantified CIA for the potential disturbance of harbour porpoise during up to two seismic surveys in the SNS SAC

UXO clearance	SCANS-III density estimate (No/km^2)	Area of potential disturbance	Potential number of harbour porpoise impacted
One seismic survey	0.888	314	279 (0.08% NS MU; 0.95% SNS SAC)
Two seismic surveys	0.888	628	558 (0.2% NS MU; 2% SNS SAC)

5.3.3 Offshore wind farm construction

80. During the construction of Norfolk Boreas there is the potential overlap with impacts from the construction activities, other than piling, of offshore wind farms.

81. There would be no additional cumulative impacts of underwater noise from other construction activities for those projects which also have overlapping piling with Norfolk Boreas as the ranges for piling would be significantly greater than those from other construction noise sources.

82. The potential impact ranges of these noise sources during offshore wind farm construction will be localised and significantly less than the ranges predicted for piling. There could be potential cumulative impacts from construction of offshore wind farms in and around the area of Norfolk Boreas.

83. The CIA includes offshore wind farms in the SNS SAC which could potentially have construction activities, other than piling, during the Norfolk Boreas construction period.

84. This highly conservative approach for offshore wind farms that could potentially have construction activities, other than piling, during the Norfolk Boreas construction period includes five offshore wind farms:

- Creyke Beck B;
- Sofia;
- East Anglia TWO;
- Thanet Extension;

- Norfolk Vanguard; and
- Hornsea Project Four.

85. The potential temporary disturbance during offshore wind farm construction activities, other than pile driving noise sources, has been based on the area of the offshore wind farm sites. This is a precautionary approach, as it is highly unlikely that construction activities, other than piling activity would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place.

86. In addition, it is unlikely, as outlined for the in-combination assessment for piling, that developers of more than one site will develop one site at a time, as it is more efficient and cost effective to develop one site and have it operational prior to constructing the next site.

87. For each project, the number of harbour porpoise in the area of each offshore wind farm site has been estimated using the latest SCANS-III density estimates (Hammond et al., 2017) for the relevant survey block that the project is located within.

88. This is a highly conservative approach for the six UK offshore wind farms that could potentially have construction activities, other than piling, during the Norfolk Boreas construction period.

89. The assessment indicates that if all six of these offshore wind farms in the southern North Sea were conducting construction activities, other than piling, at the same time, the estimated maximum in-combination area of disturbance is 2,958km^2.

90. It is important to note that these areas will not all be located within the SNS SAC.

Table 5.4 Quantified CIA for the potential disturbance of harbour porpoise during construction activities (other than piling) at offshore wind farms in the SNS SAC during construction at Norfolk Boreas.

Name of Project	Distance to NB (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of offshore wind farm site (km^2)*	Potential number of harbour porpoise disturbed
Creyke Beck B	196	O	0.888	599	532
Sofia	185	O	0.888	593	527
East Anglia TWO	73	L	0.607	255	155
Norfolk Vanguard	30	O	0.888	592	526
Thanet Extension	175	L	0.607	73	44
Hornsea Project Four	119	O	0.888	846	751
Total				**2,958**	**2,535**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.7%**

Name of Project	Distance to NB (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Area of offshore wind farm site (km²)*	Potential number of harbour porpoise disturbed
% SNS SAC (29,384 harbour porpoise)					**8.6%**

5.3.4 Offshore wind farm operation and maintenance

91. For operational offshore wind farms within (wholly or partly) the SNS SAC that could have potential in-combination effects during the Norfolk Boreas construction period, the area of the offshore wind farm that overlaps the SAC winter and summer areas has been estimated. Based on this 'potential worst-case' scenario, five other offshore wind farms located in the SNS SAC could potentially have disturbance from operational offshore wind farms and maintenance activities that overlap with construction of Norfolk Boreas.

92. The in-combination assessment indicates that, the estimated maximum in-combination area of disturbance is 1,488km^2 (Table 5.5).

93. Three of these offshore wind farms are located wholly or partly within the summer SAC area, and the estimated maximum area of disturbance for the summer SAC area is 649km^2, which represents approximately 2.4% of the summer SAC area (Table 5.5).

94. Three of these offshore wind farms are located wholly or partly within the winter SAC area, and the estimated maximum in-combination area of disturbance for the winter SAC area is 521km^2, which represents approximately 4.1% of the winter SAC area (Table 5.5).

Table 5.5 Quantified CIA for the potential disturbance of harbour porpoise during operation and maintenance activities at offshore wind farms in the SNS SAC during construction at Norfolk Boreas

Name of Project	Area of offshore wind farm site (km²)*	SCANS-III density estimate (No/km²)	Potential number of harbour porpoise disturbed
Galloper	113	0.607	69
Hornsea Project One	407	0.888	46
Hornsea Project Two	462	0.888	410
East Anglia ONE	205	0.607	124
East Anglia THREE	301	0.607	183
Total	**1,488**	-	**832**
% of North Sea MU reference population (345,373 harbour porpoise)			**0.2%**
% SNS SAC (29,384 harbour porpoise)			**2.8%**

*Source: http://www.4coffshore.com/

5.3.5 Overall cumulative impacts from noise sources (other than piling)

95. The potential cumulative impacts from noise sources (other than piling) at Norfolk Boreas and other offshore wind farms that could be constructing at the same time as Norfolk Boreas. This assessment is based on highly conservative assumptions (e.g. displacement of all harbour porpoise from the boundary of each offshore wind farm and the assumption that there is no overlap from the disturbance impacts listed).

Table 5.6 Quantified CIA for the potential disturbance of harbour porpoise from all possible noise sources (other the offshore wind farm piling) during piling at Norfolk Boreas

Potential noise sources during Norfolk Boreas piling	Area of potential disturbance	Potential number of harbour porpoise disturbed
UXO clearance (up to two operations)	4,248km^2	3,772
Seismic surveys (up to two surveys)	628km^2	558
UK and European offshore wind farm construction activities in the SNS SAC (i.e. offshore wind farm s that are not piling but potential construction activities)	2,958km^2	2,535
Operation and maintenance of UK and European offshore wind farm s in SNS SAC	1,488km^2	832
Total for other noise sources (excluding piling)	**9,322km^2**	**7,697**
% of NS MU reference population (345,373 harbour porpoise)		**2.2%**
% SNS SAC (29,384 harbour porpoise)		**26.2%**

5.4 Summary of the cumulative underwater noise impacts (Impacts 1 and 2)

96. This section considers the overall cumulative impact of underwater noise associated with piling (cumulative impact 1) and other noise sources (cumulative impact 2). There would be no additional cumulative impacts of noise from other construction activities for those projects which also have overlapping piling with Norfolk Boreas as the impact ranges for piling would be significantly greater than those impacts from other construction noise sources.

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

Table 5.7 Quantified CIA for the potential disturbance of harbour porpoise from all possible noise sources during construction at Norfolk Boreas

Potential noise sources during Norfolk Boreas piling	Maximum area of potential disturbance	Potential number of harbour porpoise impacted
Offshore wind farm projects, including Norfolk Boreas, with 'likely overlap' of single pile installation (see Impact 1)	6,784km^2	6,024
UXO clearance (up to operations)	4,248km^2	3,772
Seismic surveys (up to 2 surveys)	628km^2	558
UK and European offshore wind farm construction activities in the SNS SAC (i.e. offshore wind farm s that are not piling but potential construction activities)	2,958km^2	2,535
Operation and maintenance of offshore wind farm s in SNS SAC	1,488km^2	832
Total		**13,721**
% of reference population (345,373 harbour porpoise)		**4.0%**
% SNS SAC (29,384 harbour porpoise)		**46.7%**

5.5 Changes in prey availability

98. The cumulative assessment for potential changes to prey availability has assumed that any potential impacts on harbour porpoise prey species from underwater noise, including piling, would be the same or less than those for harbour porpoise. Therefore, there would be no additional impacts other than those assessed for harbour porpoise, i.e. if prey are disturbed from an area as a result of underwater noise, harbour porpoise will be disturbed from the same or greater area, therefore any changes to prey availability would not affect harbour porpoise as they would already be disturbed from the same area.

99. 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.

5.6 Increased collision risk

100. The potential increased collision risk with vessels during the construction of offshore wind farms has used a precautionary approach. Vessel movements to and from any port will be incorporated within existing vessel routes and therefore the increased risk for any vessel interaction is within the wind farm site. Therefore, the number of harbour porpoise that could be at increased collision risk with vessels has been assessed based on 5% of the number of animals that could be present in the wind

farm area. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the wind farm areas would be at increased collision risk with vessels.

101. 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.

Table 5.8 Quantified CIA for the potential increased collision risk with vessels for harbour porpoise during offshore wind farm construction

Name of Project	Tier	Distance to NB (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of offshore wind farm site*	Potential number of harbour porpoise at increased collision risk
Norfolk Boreas	5	0	O[3]	0.888	727	32
Creyke Beck A	3	163	O	0.888	515	23
Creyke Beck B	3	193	O	0.888	599	27
Teesside A	3	180	N	0.837	562	24
Sofia	3	175	O[2]	0.888	593	26
Norfolk Vanguard	4	30	O[1]	0.888	592	26
Hornsea Project 3	4	88	O	0.888	695	31
Thanet Extension	4	165	L	0.607	73	2
East Anglia ONE North	5	30	L	0.607	206	6
East Anglia TWO	5	45	L	0.607	255	8
Hornsea Project Four	5	119	O	0.888	846	38
Total						**243**
% of North Sea MU reference population (345,373 harbour porpoise)						**0.07%**
% SNS SAC (29,384 harbour porpoise)						**0.8%**

[1]NV East is located in SCANS-III survey block L, NV West is located in both SCANS-III survey block L and survey block O; therefore higher density estimate from survey block O is used.
[2]Dogger Bank Zone Teesside B overlaps SCANS-III survey block O & N, but majority of site is in block O.
[3]Norfolk Boreas overlaps SCANS-III survey block O & L; therefore higher density estimate from survey block O is used.
*Source: http://www.4coffshore.com/

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