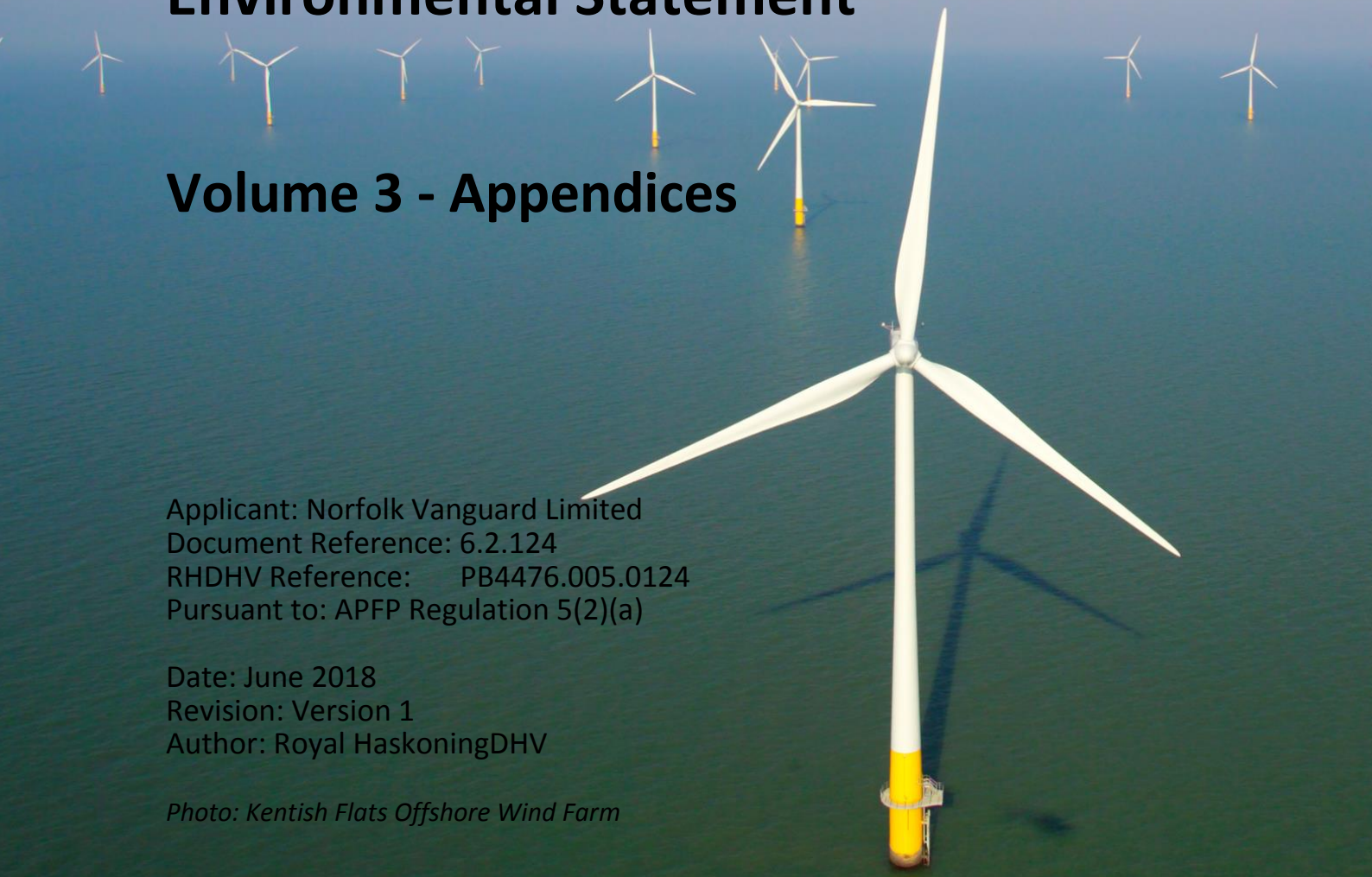
Norfolk Vanguard Offshore Wind Farm

Appendix 12.4

Additional Assessment in relation to the Southern North Sea candidate Special Area of Conservation (cSAC)

Environmental Statement

Volume 3 - Appendices



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Environmental Impact Assessment
Environmental Statement

Document Reference: PB4476.005.0124

June 2018

For and on behalf of Norfolk Vanguard Limited

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Table of Contents

Tables

Glossary

ADD	Acoustic Deterrent Device
CI	Confidence Interval
CIA	Cumulative Impact Assessment
cSAC	Candidate Special Area of Conservation
CV	Confidence Variation
dB	Decibels
DWR	Deep Water Route
EPP	Evidence Plan Process
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
HP	Harbour porpoise
HRA	Habitats Regulations Assessment
JNCC	Joint Nature and Conservation Committee
kJ	Kilojoules
km	Kilometre
Km^2	Kilometre squared
MMMP	Marine Mammal Mitigation Protocol
MU	Management Unit
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
NS	North Sea
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
O&M	Operation and Maintenance
OWF	Offshore Wind Farm
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SEL	Sound Exposure Level
SCANS	Small Cetaceans in the European Atlantic and North Sea
SIP	Site Integrity Plan
SMRU	Sea Mammal Research Unit
SNCB	Statutory Nature Conservation Body
SNS	Southern North Sea
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
UK	United Kingdom
UXO	Unexploded Ordnance

Terminology

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

1 INTRODUCTION

1.1 Purpose of this Document

1. The Southern North Sea (SNS) candidate Special Area of Conservation (cSAC) has been recognised as an area with persistent high densities of harbour porpoise (JNCC, 2017a). The cSAC has a surface area of 36,951km^2 and covers both winter and summer habitats of importance to harbour porpoise, with approximately 66% of the candidate site being important in the summer and the remaining 33% of the site being important in the winter period (JNCC, 2017a).

2. Both NV East and NV West lie wholly within the SNS cSAC (see Figure 12.1 of the Environmental Statement (ES) Volume 2). NV East is located wholly within the summer area. The majority of NV West is located within the summer area, with a small segment of the southern edge of the site being located within the winter area.

3. The SNS cSAC Site Selection Report (JNCC, 2017a) identifies that the SNS cSAC site could support approximately 18,500 individuals (95% 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 SCANS-II survey in July 2005) it cannot be considered as an estimated population for the site. It is therefore not appropriate to use site population estimates in any assessments of effects of plans or projects, 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).

4. 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.

5. However, it was agreed with the marine mammal Expert Topic Group (ETG) at the meeting on 15th February 2017 that the estimate that the SNS cSAC could support 17.5% of the UK North Sea reference population would be assessed in a separate appendix for information.

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

2 POTENTIAL IMPACTS DURING CONSTRUCTION

2.1 Impact 1: Underwater noise during UXO clearance

7. Caution should also be raised over the longer range SPL_{peak} values. Peak noise levels are difficult to predict accurately in a shallow water environment (von Benda Beckmann, 2015) and would tend to be significantly over-estimated over ranges of the order of 3,000m compared to real data. Therefore, the use of SEL is considered preferential at long range (Chapter 5 Project Description, Appendix 5.4). However, as a precautionary approach and based on the current Natural England advice (20180209 NE position on NOAA UXOs and EPS) the assessment has been based on the worst-case scenarios for the unweighted SPL_{peak} predicted PTS impact ranges and weighted SEL predicted TTS impact ranges.

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

Table 1 Potential impact of permanent auditory injury (PTS) on harbour porpoise during UXO clearance without mitigation

Potential Impact	TNT Equivalent / Charge weights SOURCE LEVEL, SPL_{PEAK}	55kg 287.4 dB	120kg 290.0 dB	150kg 290.7 dB	250kg 292.4 dB	261kg 292.5 dB	525kg 294.8 dB	770kg 296.1 dB
PTS SPL_{peak} Unweighted (NMFS, 2016)	202 dB re 1 µPa	5.4km	6.8km	7.3km	8.4km	8.5km	10.4km	11.5km
PTS SEL Weighted (NMFS, 2016)	155 dB re 1 μPa^2s	1.2km	1.7km	1.9km	2.4km	2.4km	3.3km	3.9km
Number of harbour porpoise and % of reference population based on maximum impact range (11.5km) for unweighted SPL_{peak} (NMFS, 2016)		Maximum impact area* based on unweighted SPL_{peak} = 415.5km^2 368.5 harbour porpoise (0.1% of NS MU; 1.25% SNS cSAC) based on SCANS-III survey density (0.888/km^2). 523.5 harbour porpoise (0.15% of NS MU; 1.8% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East+						

*Maximum area based on area of circle with maximum impact range for radius;
+Worst-case scenario based on greatest density estimate for the NV West and NV East sites.

Table 2 Potential maximum impact of temporary auditory injury (TTS) and fleeing response on harbour porpoise during UXO clearance

Potential Impact	TNT Equivalent / Charge weights SOURCE LEVEL, SPL_{PEAK}	55kg 287.4 dB	120kg 290.0 dB	150kg 290.7 dB	250kg 292.4 dB	261kg 292.5 dB	525kg 294.8 dB	770kg 296.1 dB
TTS SPL_{peak} Unweighted (NMFS, 2016)	196 dB re 1 µPa	9.2km	11.4km	12.1km	13.9km	14.0km	16.8km	18.4km
TTS SEL Weighted (NMFS, 2016)	140 dB re 1 μPa^2s	11.5km	14.9km	16.0km	18.7km	18.9km	23.0km	25.5km
Number of harbour porpoise and % of reference population based on maximum impact range (25.5km) for TTS SEL Weighted (NMFS, 2016)		Maximum impact area* based on weighted TTS SEL = 2,043km^2 1,814 harbour porpoise (0.5% of NS MU; 6.2% SNS cSAC) based on SCANS-III survey density (0.888/km^2). 2,574 harbour porpoise (0.7% of NS MU; 8.8% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East+						

*Maximum area based on area of circle with maximum impact range for radius;
+Worst-case scenario based on greatest density estimate for the NV West and NV East sites.

9. 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.

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

Table 3 Estimated number of harbour porpoise potentially disturbed during UXO clearance

Potential Impact	Estimated number in impact area	% of reference population (% SNS cSAC)
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). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.55% of NS MU (6.4% SNS cSAC) based on SCANS-III density. 0.8% of NS MU (9.1% SNS cSAC) based on the most conservative site specific survey density (NV East).

11. The spatial assessment of the potential effects of disturbance during UXO clearance on the SNS cSAC is assessed in the information for the HRA. This takes into account the potential maximum and average area of possible displacement of harbour porpoise based on the worst-case scenario for UXO clearance at NV East, NV West and the offshore cable corridor.

2.2 Impact 2: Underwater noise during piling

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

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

14. Mitigation, such as the activation of ADDs prior to the first strike of the soft-start would allow harbour porpoise to move away prior to the soft start and ramp up, therefore reducing the number of animals within the PTS impact range for the first strike of the soft-start. For example, the activation of ADDs for just 10 minutes prior to the soft-start would allow harbour porpoise to move at least 0.9km from the piling location (based on a precautionary average swimming speed of 1.5m/s), which is beyond the maximum PTS predicted impact range of 0.42km for the starting hammer energy of up to 500kJ. Therefore, after the ADD activation there should be no harbour porpoise in the potential impact range for PTS from the first strike of the soft-start and therefore with mitigation the potential magnitude would be negligible.

15. The embedded mitigation for piling, would reduce the risk of PTS from a single strike at the maximum hammer energy by allowing harbour porpoise to move away during soft start and ramp up, therefore reducing the number of harbour porpoise within the PTS impact range. For example, during the minimum 30 minutes for the soft-start and ramp-up it is estimated that animals would move over 2.7km from the piling location (based on a precautionary average swimming speed of 1.5m/s), which, with the 10 minute ADD activation, the minimum distance would be 3.6km, which is greater than the maximum predicted range for PTS of 2.8km for harbour porpoise. As a result, the potential magnitude of effect would be negligible.

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

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

Table 4 Maximum number of harbour porpoise (and % of reference population; % SNS cSAC) 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; % SNS cSAC) with no mitigation.		
PTS without mitigation – single strike	NMFS (2016) unweighted SPL_{peak} 202 dB re 1 µPa	17 harbour porpoise (0.005% NS MU; 0.06% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 24 harbour porpoise (0.007% NS MU; 0.08% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 15 harbour porpoise (0.004% NS MU; 0.05% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.	8 harbour porpoise (0.002% NS MU; 0.03% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 12 harbour porpoise (0.003% NS MU; 0.04% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 8 harbour porpoise (0.002% NS MU; 0.03% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.	0.5 harbour porpoise (0.0001% NS MU; 0.002% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 0.8 harbour porpoise (0.0002% NS MU; 0.003% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 0.5 harbour porpoise (0.0001% NS MU; 0.002% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.
PTS – cumulative exposure (including soft-start and ramp-up)	NMFS (2016) SEL_{cum} Weighted 155 dB re 1 µPa^{2}s	0.2 harbour porpoise (0.00006% NS MU; 0.0007% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 0.25 harbour porpoise (0.00007% NS MU; 0.00085% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 0.16 harbour porpoise (0.00005% NS MU; 0.0005% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.	3 harbour porpoise (0.0009% NS MU; 0.01% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 4.3 harbour porpoise (0.001% NS MU; 0.015% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 2.7 harbour porpoise (0.0008% NS MU; 0.009% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.	N/A

Table 5 Maximum number of harbour porpoise (and % of reference population; % SNS cSAC) 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; % SNS cSAC)	
		Monopile with maximum hammer energy of 5,000kJ	Pin-pile with maximum hammer energy of 2,700kJ
TTS / fleeing response – single strike	NMFS (2016) unweighted SPL_{peak} 196 dB re 1 µPa	78 harbour porpoise (0.02% NS MU; 0.3% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 111 harbour porpoise (0.03% NS MU; 0.4% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 70 harbour porpoise (0.02% NS MU; 0.2% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.	39 harbour porpoise (0.01% NS MU; 0.1% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 55 harbour porpoise (0.02% NS MU; 0.2% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 35 harbour porpoise (0.01% NS MU; 0.1% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.
TTS / fleeing response without mitigation – cumulative exposure	NMFS (2016) SEL_{cum} Weighted 140 dB re 1 µPa^{2}s	122 harbour porpoise (0.04% NS MU; 0.4% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 174 harbour porpoise (0.05% NS MU; 0.6% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 109 harbour porpoise (0.03% NS MU; 0.8% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.	796 harbour porpoise (0.2% NS MU; 2.7% SNS cSAC) based on SCANS-III survey block O density (0.888/km^2). 1,130 harbour porpoise (0.3% NS MU; 3.8% SNS cSAC) based on site specific survey density (1.26/km^2) at NV East. 708 harbour porpoise (0.2% NS MU; 2.4% SNS cSAC) based on site specific survey density (0.79/km^2) at NV West.

Table 6 Estimated number of harbour porpoise (and % of reference population; % SNS cSAC) potentially disturbed during piling based on 26km range from piling location

Potential Impact	Estimated number in impact area	% of reference population (% SNS cSAC)
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). 2,676 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 1,678 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.6% of NS MU (6% SNS cSAC) based on SCANS-III density. 0.8% of NS MU (9% SNS cSAC) based on site specific survey density at NV East. 0.5% of NS MU (6% SNS cSAC) based on site specific survey density at NV West.
Two concurrent piling events in NV West (3,520km^2)	3,126 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 2,781 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.9% NS MU (11% SNS cSAC) based on SCANS-III density. 0.8% of NS MU (9.5% SNS cSAC) based on site specific survey density at NV West.
Two concurrent piling events in NV East (3,508km^2)	3,115 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,420 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.9% of NS MU (11% SNS cSAC) based on SCANS-III density. 1.3% of NS MU (15% SNS cSAC) based on site specific survey density at NV East.
Two concurrent piling events based on one worst-case location in NV East and one worst-case location NV West (4,248km^2)	3,772 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,354 harbour porpoise based on site specific survey density at NV East and NV West.	1% of NS MU (13% SNS cSAC) based on SCANS-III density. 1.3% of NS MU (15% SNS cSAC) based on site specific survey density at NV East & NV West.

Table 7 Estimated number of harbour porpoise (and % of reference population; % SNS cSAC) 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 (% SNS cSAC)	Estimated number based on 75% of individuals in area responding	% of reference population (% SNS cSAC)	Estimated number based on 50% of individuals in area responding	% of reference population (% SNS cSAC)
Possible behavioural response to underwater noise during piling – maximum hammer energy for monopile (18,668km^2)	16,577 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 23,522 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 14,748 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	5% of NS MU (56% SNS cSAC) based on SCANS-III density. 7% of NS MU (80% SNS cSAC) based on site specific survey density at NV East. 4% of NS MU (50% SNS cSAC) based on site specific survey density at NV West.	12,433 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 17,642 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 11,061 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	4% of NS MU (42% SNS cSAC) based on SCANS-III density. 5% of NS MU (60% SNS cSAC) based on site specific survey density at NV East. 3% of NS MU (38% SNS cSAC) based on site specific survey density at NV West.	8,289 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 11,761 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 7,374 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	2% of NS MU (28% SNS cSAC) based on SCANS-III density. 3% of NS MU (40% SNS cSAC) based on site specific survey density at NV East. 2% of NS MU (25% SNS cSAC) based on site specific survey density at NV West.
Possible behavioural response to underwater noise during piling – maximum hammer energy for pin-pile (12,666km^2)	11,247 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 15,959 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 10,006 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	3% of NS MU (38% SNS cSAC) based on SCANS-III density. 5% of NS MU (54% SNS cSAC) based on site specific survey density at NV East. 3% of NS MU (34% SNS cSAC) (based on site specific survey density at NV West.	8,435 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 11,969 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 7,505 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	2% of NS MU (29% SNS cSAC) based on SCANS-III density. 3.5% of NS MU (41% SNS cSAC) based on site specific survey density at NV East. 2% of NS MU (26% SNS cSAC) based on site specific survey density at NV West.	5,624 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 7,980 harbour porpoise based on site specific survey density (1.26/km^2) at NV East. 5,003 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	2% of NS MU (19% SNS cSAC) based on SCANS-III density. 2% of NS MU (27% SNS cSAC) based on site specific survey density at NV East. 1% of NS MU (17% SNS cSAC) based on site specific survey density at NV West.

2.3 Impact 3: Underwater noise during other construction activities

17. As a precautionary worse-case scenario, the number of harbour porpoise that could be disturbed as a result of underwater noise during construction from activities other than piling and vessel movements has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor.

18. This is very precautionary, as it is highly unlikely that construction activities, other than piling activity, could result in disturbance of all harbour porpoise from the entire wind farm area and the offshore cable corridor. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

19. Based on a more realistic, but precautionary approach that up to 50% of all individuals could potentially be disturbed from the wind farm sites and offshore cable corridor area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population; 1.5% SNS cSAC) could be temporarily displaced.

Table 8 Estimated number of harbour porpoise (and % of reference population; % SNS cSAC) that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor)

Potential Impact Area	Estimated number in impact area	% of reference population (% SNS cSAC)
NV East area (297km^2)	264 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 374 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.08% of NS MU (0.9% SNS cSAC) based on SCANS-III density. 0.1% of NS MU (1% SNS cSAC) based on site specific survey density at NV East.
NV West area (295km^2)	262 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 233 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.08% of NS MU (0.9% SNS cSAC) based on SCANS-III density. 0.07% of NS MU (0.8% SNS cSAC) based on site specific survey density at NV West.
Offshore cable corridor (237km^2)	210.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 299 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.06% of NS MU (0.7% SNS cSAC) based on SCANS-III density. 0.09% of NS MU (1% SNS cSAC) based on site specific survey density at NV East.
Total offshore project area (829km^2)	736.5 harbour porpoise based on SCANS-III survey block O density. 906harbour porpoise based on site specific survey densities for NV East and NV West.	0.2% of NS MU (2.5% SNS cSAC) based on SCANS-III density. 0.3% of NS MU (3% SNS cSAC) based on site specific survey density.

2.4 Impact 4: Vessel underwater noise and disturbance

20. Maximum number of vessels on site at any one time during construction is estimated to be 57 vessels.

21. Underwater noise generated by vessels would not be sufficient to cause PTS or other injury to harbour porpoise. The potential for TTS is only likely if the animal remains in very close proximity to a vessel for a prolonged period of time, which is highly unlikely. Disturbance is therefore the only potential underwater noise effect associated with vessels.

22. 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).

23. Chapter 15 Shipping and Navigation provides a description of the baseline conditions and anticipated additional ship movements arising from the construction and operation of the proposed project.

24. Throughout the summer period of the marine traffic survey, there was on average 69 unique vessels per day recorded within NV East, 46 unique vessels per day recorded within the NV West and on average 96 unique vessels per day recorded within the offshore cable corridor. Throughout the winter period of the marine traffic survey, there was on average 63 unique vessels per day recorded within the NV East, 39 unique vessels per day recorded within the NV West and on average 92 unique vessels per day recorded within the offshore cable corridor. The majority of vessels recorded were cargo vessels and tankers, with most of these vessels utilising the IMO Routeing Measures in the area; however other main routes were identified outwith the Deep Water Routes (DWR), including routes which intersected the OWF sites. Fishing activity was also notable in the area (Chapter 15 Shipping and Navigation). Indicating an already relatively high shipping activity in and around Norfolk Vanguard.

25. There would be some re-routing of existing vessels around the Norfolk Vanguard site, with a minimum passing distance of 500m from areas where construction is underway. This is likely to re-route existing large and fast moving vessels (predominantly general cargo ships).

26. The maximum number of vessels on site at any one time during construction is estimated to be 57 vessels. This could therefore represent up to a 27% increase in

the number of vessels during the summer period and 29% increase in the number of vessels during the winter periods, compared to current baseline vessel numbers.

27. The maximum number of 57 vessels at any one time in the offshore project area (829km^2) during construction would be significantly less than the Heinänen and Skov (2015) threshold of 80 vessels per day within an area of 5km^2. Based on the precautionary worst-case scenario, including existing vessel movements in around the Norfolk Vanguard area, but taking into account that other vessels would be restricted from entering the immediate construction site (with a 500m safety zone around construction vessels and partially installed foundations), the number of vessels would be unlikely to exceed the Heinänen and Skov (2015) threshold level of 80 vessels per day in a 5km^2 area. Therefore, there unlikely to be is the potential for significant disturbance to harbour porpoise as a result of the increased number of vessels during construction.

28. As a precautionary worse-case scenario approach the number of harbour porpoise that could be disturbed as a result of underwater noise from vessels has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8). This is very precautionary, as it is highly unlikely that underwater noise from vessels could result in disturbance from the entire wind farm area and the offshore cable corridor at any one time. Any disturbance is likely to be limited to the immediate vicinity around the actual vessel.

29. Underwater noise and disturbance from additional vessels during construction are likely to be localised in comparison to existing shipping noise. The disturbance of harbour porpoise from the presence and underwater noise of vessels would be temporary as the vessels move in and out of the site and move between different locations within the site, harbour porpoise would be expected to return to the area once the disturbance had ceased or they had become habituated to the sound.

30. Based on a more realistic, but precautionary approach that up to 50% of all individuals could potentially be disturbed from the wind farm sites and offshore cable corridor area, approximately 453 harbour porpoise (0.1% of the North Sea MU reference population; 1.5% SNS cSAC) could be temporarily displaced. The magnitude of effect in all species is **negligible**, with less than 1% of the reference population being likely to be temporarily affected.

2.5 Impact 5: Barrier effects from underwater noise

31. The spatial worst-case is the maximum area (4,248km^2) over which potential disturbance could occur at any one time based on two concurrent foundations being installed (Table 6). However, as this would only be a relatively small duration of the potential construction period.

32. The duration of concurrent piling, for two concurrent locations would be approximately half the total maximum duration for single pile installation, as well as reducing the overall construction window. The maximum concurrent piling duration (including ADD activation) for Norfolk Vanguard would be up to 699.5 hours (equivalent of up to approximately 29.5 days).

33. For the single phase approach this would be approximately 5% of the 20 month (608 days) foundation installation period and 4% of the 23 month (700 day) overall construction period.

34. For the two phase approach this would be approximately 15 days per phase and therefore 6% of each of the two eight month (243 day) foundation installation periods and 4% of the two 12 month (365 day) overall construction periods.

35. 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.

2.6 Impact 6: Vessel collision risk

36. During the construction of Norfolk Vanguard there will be an increase in vessel traffic. Vessels will follow established shipping routes utilising the shipping lane between NV East and NV West and routes to the relevant ports in order to minimise vessel traffic in the wider area.

37. For Norfolk Vanguard West and Norfolk Vanguard East, alone or for the two sites combined, the overall worst-case scenario for vessel movements during construction would be:

- 1,180 two-way vessel movements based on a Single Phase approach; or
- 1,180 (590 x2) two-way vessel movements for a Two Phased approach.

38. The construction port to be used for Norfolk Vanguard is not yet known and could be located on the south east coast of England. Indicative daily vessel movements (return trips to a local port) during construction of Norfolk Vanguard are estimated to be an average of two per day.

39. As a precautionary worse-case scenario, the number of harbour porpoise that could be at increased collision with vessels during construction has been assessed based on the number of animals that could be present in the wind farm areas and the

offshore cable corridor and the number that could potentially be at increased collision risk based on 90-95% avoidance rates.

40. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Vanguard 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.

41. Vessel movements, where possible, will be incorporated into recognised vessel routes and hence to areas where harbour porpoise 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 harbour porpoise.

42. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed from the Norfolk Vanguard offshore wind farm site and cable corridor as a result of underwater noise from construction activities and vessels, there should be no potential for increased collision risk with vessels at Norfolk Vanguard during the construction period.

Table 9 Estimated number of harbour porpoise that could be present in the Norfolk Vanguard offshore area (wind farm sites and cable corridor) at potential increased collision risk based on 95-90% avoidance

Potential Impact Area	Estimated number at potential increased collision risk based on 95-90% avoidance	% of reference population (% SNS cSAC)
Total offshore project area (829km^2)	37-74 harbour porpoise based on SCANS-III survey block O density. 45-91 harbour porpoise based on site specific survey densities for NV East and NV West.	0.01-0.02% of NS MU (0.1-0.2% SNS cSAC) based on SCANS-III density. 0.01-0.03% of NS MU (0.15-0.3% SNS cSAC) based on site specific survey density.

2.7 Impact 7: Changes to prey resource

43. 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 wind farm area and the offshore cable corridor (Table 8). 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.

44. Based on a more realistic, but precautionary approach that any changes in prey resource could occur affect up to 50% of harbour porpoise that could potentially be present in the wind farm sites and offshore cable corridor area, this would result in up to approximately 453 harbour porpoise (0.1% of the North Sea MU reference population; 1.5% SNS cSAC) could be temporarily displaced.

45. 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.

2.8 Impact 8: Changes to water quality

46. As a very precautionary approach the number of harbour porpoise that could potentially encounter increased suspended sediments during construction has been assessed for the total offshore project area (Table 8).

3 POTENTIAL IMPACTS DURING OPERATION

47. 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 1: Underwater noise from operational turbines

48. 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).

49. As a precautionary worse-case scenario, the number of harbour porpoise that could be disturbed as a result of underwater noise from operational turbines has been assessed based on the number of animals that could be present in the wind farm area (Table 10). This is very precautionary, as it is highly unlikely that underwater noise from operational wind turbines could result in disturbance from the entire wind farm area.

50. Therefore values have been presented for three scenarios; 0% disturbance, as there is currently no evidence of any significant disturbance of harbour porpoise or seals from operational wind farm sites; a precautionary 50% disturbance; and a very worst-case of a 100% disturbance from the offshore wind farm areas as a result of underwater noise from operational turbines (Table 10).

Table 10 Estimated number of harbour porpoise (and % of reference population and % SNS cSAC) that could be disturbed from the Norfolk Vanguard offshore wind farm area during operation based on 100%, 50% and 0% disturbance as a result of operational turbine noise

Potential Impact Area	Receptor	Estimated number in potential impact area			% of reference population (% SNS cSAC)		
		100%	50%	0%	100%	50%	0%
Total offshore wind farm area (592km^2)	Harbour porpoise	526 based on SCANS-III density (0.888/km^2). 607 based on densities at each site.	263 based on SCANS-III density (0.888/km^2). 303.5 based on densities at each site.	0	0.2% of NS MU (1.8% SNS cSAC) based on SCANS-III density. 0.2% of NS MU (2% SNS cSAC) based on densities at each site.	0.08% of NS MU (0.9% SNS cSAC) based on SCANS-III density. 0.09% of NS MU (1% SNS cSAC) based on densities at each site.	0

3.2 Impact 2: Underwater noise from maintenance activities

51. 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.

52. As a precautionary worse-case scenario approach the number of harbour porpoise that could be disturbed as a result of underwater noise from maintenance activities has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8).

53. This is very precautionary, as it is highly unlikely that maintenance activities could result in disturbance from the entire wind farm area and the offshore cable corridor. Any disturbance is likely to be limited to the area in and around where the actual activity is actually taking place.

3.3 Impact 3: Vessel underwater noise and disturbance during operation and maintenance

54. Taking into account the existing vessel movements in around the Norfolk Vanguard 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 Vanguard.

55. As a precautionary worse-case scenario approach the number of harbour porpoise that could be disturbed as a result of underwater noise from vessels during operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8).

56. 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.

3.4 Impact 4: Vessel collision risk

57. Based on the worst-case scenario of an average of two vessel movements per day, the increase in vessels movement per day at the Norfolk Vanguard site (up to approximately 480 round trips per year) during operation and maintenance is relatively small compared to existing vessel traffic.

58. 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 wind farm area and the offshore cable corridor and the number that could potentially be at increased collision risk based on 90-95% avoidance rates (Table 9).

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

3.5 Impact 5: Changes to prey resource during operation and maintenance

60. As a precautionary worst-case scenario approach the number of harbour porpoise that could be impacted as a result of changes to prey resources during operation and maintenance has been assessed based on the number of animals that could be present in the wind farm area and the offshore cable corridor (Table 8). This is very precautionary, as it is highly unlikely that any changes in prey resources could occur over the entire wind farm area and the offshore cable corridor during operation and maintenance.

4 POTENTIAL IMPACTS DURING DECOMMISSIONING

61. 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 1: Underwater noise from foundation removal

62. 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.

63. 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 2: Barrier effects from underwater noise

64. 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 3: Vessel underwater noise and disturbance from vessels

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

4.4 Impact 4: Vessel collision risk

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

4.5 Impact 5: Changes to prey resource

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

4.6 Impact 6: Changes to water quality

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

5 CUMULATIVE IMPACTS

5.1 Approach

69. 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 cSAC could potentially support than it follows that impacts must be limited to those occurring within the SNS cSAC 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 NS MU population as per the ES).

5.2 Impact 1: Underwater noise impacts during construction from OWF piling

70. 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. 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 CIA.

71. 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.

72. 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.

73. The potential disturbance from OWFs during construction activities other than pile driving noise sources, including vessels, seabed preparation, rock dumping and cable installation, has been based on the area of the OWF sites, 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.

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

75. 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.

76. The conservative potential worst-case scenario for OWFs that could be piling at the same time as Norfolk Vanguard in the SNS cSAC includes four other UK OWFs:

- Creyke Beck B
- Sofia
- Hornsea Project 3
- East Anglia TWO

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

78. Based on a single pile installation at each of the five OWFs, the estimated maximum area of potential disturbance is 10,620km^2, without any overlap in the potential areas of disturbance at each wind farm or between wind farms.

79. In this assessment (different from the ES and HRA) the number of harbour porpoise that could be disturbed has been estimated based on the potential area of overlap with the SNS cSAC (Table 11). 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 cSACs areas that are suitable to use, as the data Heinänen and Skov (2015) covers the wider area).

Table 11 Estimated maximum, minimum and average overlap with SNS cSAC winter and summer areas and number of harbour porpoise (% of reference population and % SNS cSAC) for potential worst-case scenarios (Sofia, Dogger Bank Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single and concurrent piling and the number of harbour porpoise that could be disturbed from these areas in the SNS cSAC

In-combination assessment scenario	Maximum area overlap with SNS cSAC	Minimum area overlap with SNS cSAC	Average area overlap with SNS cSAC
Potential worst-case scenario (5 OWFs) – single piling	Maximum overlap with summer SNS cSAC area = 5,458km^2 [4,847 harbour porpoise (1.4% NS MU; 16.5% SNS CSAC)] Maximum overlap with winter SNS cSAC area = 3,056km^2 [2,714 harbour porpoise (0.8% NS MU; 9% SNS cSAC)] Total maximum overlap with SNS cSAC = 8,514km^2 [7,561 harbour porpoise (2% NS MU; 26% SNS cSAC)]	Minimum overlap with summer SNS cSAC area = 3,078km^2 [2,733 harbour porpoise (0.8% NS MU; 9% SNS cSAC)] Minimum overlap with winter SNS cSAC area = 2,130km^2 [1,891 harbour porpoise (0.6% NS MU; 6% SNS cSAC)] Total minimum overlap with SNS cSAC = 5,208km^2 [4,624 harbour porpoise (1% NS MU; 16% SNS cSAC)]	Average overlap with summer SNS cSAC area = 4,268km^2 [3,790 harbour porpoise (1% NS MU; 13% SNS cSAC)] Average overlap with winter SNS cSAC area = 2,593km^2 [2,303 harbour porpoise (0.7% NS MU; 8% SNS cSAC)] Total average overlap with SNS cSAC = 6,861km^2 [6,093 harbour porpoise (2% NS MU; 21% SNS cSAC)]
Potential worst-case scenario (5 OWFs) – concurrent piling	Maximum overlap with summer SNS cSAC area = 7,332km^2 [6,511 harbour porpoise (2% NS MU; 22% SNS cSAC)] Maximum overlap with winter SNS cSAC area = 4,834km^2 [4,293 harbour porpoise (1% NS MU; 15% SNS cSAC)] Total maximum overlap with SNS cSAC = 12,166km^2 [10,804 harbour porpoise (3% NS MU; 37% SNS cSAC)]	Minimum overlap with summer SNS cSAC area = 3,150km^2 [2,797 harbour porpoise (0.8% NS MU; 9.5% SNS cSAC)] Minimum overlap with winter SNS cSAC area = 2,214km^2 [1,966 harbour porpoise (0.6% NS MU; 7% SNS cSAC)] Total minimum overlap with SNS cSAC = 8,514km^2 [4,763 harbour porpoise (1% NS MU; 16% SNS cSAC)]	Average overlap with summer SNS cSAC area = 5,241km^2 [4,654 harbour porpoise (1% NS MU; 18% SNS cSAC)] Average overlap with winter SNS cSAC area = 3,525km^2 [3,130 harbour porpoise (0.9% NS MU; 11% SNS cSAC)] Total average overlap with SNS cSAC = 8,766km^2 [7,784 harbour porpoise (2% NS MU; 26.5% SNS cSAC)]

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

5.3.1 UXO clearance

80. 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 Vanguard project would not contribute to any cumulative impacts for lethal injury, physical injury and permanent auditory injury (PTS), therefore the CIA only considers potential disturbance effects.

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

82. It is 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 cSAC area;

ii) both are in the winter cSAC area; or

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

83. 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.

84. If two UXO detonations were undertaken at the same time the potential area of disturbance could be 4,248km^2, which is approximately 16% of summer cSAC area and 32% of the winter cSAC area.

85. If one UXO detonation was undertaken, the potential area of disturbance could be (2,124km^2) which would be approximately 8% of summer cSAC area and 16% of the winter cSAC area.

86. 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).

87. 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 cSAC.

Table 12 Quantified CIA for the potential disturbance of harbour porpoise (and % of reference population and % SNS cSAC) during up to two UXO clearance operations in the SNS cSAC

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 cSAC)
Two UXO clearance operations	0.888	4,248km^2	3,772 (1% NS MU: 13% SNS cSAC)

5.3.2 Seismic surveys

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

89. It is 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 cSAC area;

    ii) both are in the winter cSAC area; or

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

90. 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).

91. 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 EPS in relation to deliberate injury or disturbance offences.

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

93. 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).

94. 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 cSAC.

Table 13 Quantified CIA for the potential disturbance of harbour porpoise during up to two seismic surveys in the SNS cSAC

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 cSAC)
Two seismic surveys	0.888	628	558 (0.2% NS MU; 2% SNS cSAC)

5.3.3 OWF construction

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

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

97. The potential impact ranges of these noise sources during OWF construction will be localised and significantly less than the ranges predicted for piling. There could be potential cumulative impacts from construction of OWFs in and around the area of Norfolk Vanguard.

98. The CIA includes OWFs in the SNS cSAC which could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period.

99. This highly conservative approach for OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period includes six OWFs:

- Creyke Beck A
- Teesside A
- East Anglia THREE
- East Anglia ONE North
- Thanet Extension
- Norfolk Boreas

100. The potential temporary disturbance during OWF construction activities, other than pile driving noise sources, has been based on the area of the OWF sites. This is a precautionary approach, as it is highly unlikely that construction activities, other

than piling activity would result in disturbance from the entire wind farm area. Any disturbance is likely to be limited to the area in and around where the activity is actually taking place.

101. In addition, it is likely, 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.

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

103. Based on this highly conservative approach for the six UK OWFs that could potentially have construction activities, other than piling, during the Norfolk Vanguard construction period.

104. The assessment indicates that if all six of these OWFs in the southern North Sea were conducting construction activities, other than piling, at the same time, the estimated maximum in-combination area of disturbance in the summer SNC cSAC area is 1,567km^2 and 482km^2 in the winter area.

105. However, based on the precautionary, but more realistic scenario that up to 50% of harbour porpoise could be disturbed from offshore wind farm sites as a result of construction activities, other than piling, at the same time, the estimated maximum in-combination area of disturbance is 783.5km^2 in the summer are and 241km^2.

Table 14 Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at OWFs in the SNS cSAC during construction at Norfolk Vanguard

Name of Project	Area of OWF site (km^2)*	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Creyke Beck A	515	515	0
Teesside A		0	0
East Anglia THREE	301	301	203
Norfolk Boreas	727	704	0
Thanet Extension	73	0	73
East Anglia ONE North	206	47	206
Total area	**1,822km^2**	**1,567km^2**	**482km^2**
Number of harbour porpoise (100% disturbance; based on SCANS-III density estimate of 0.888/km^2)		**1,392**	**428**

Name of Project	Area of OWF site (km²)*	Area in summer cSAC area (km²)	Area in winter cSAC area (km²)
% of North Sea MU reference population (345,373 harbour porpoise)		**0.4%**	**0.1%**
% SNS cSAC (29,384 harbour porpoise)		**4.7%**	**1.5%**
Number of harbour porpoise (50% disturbance; based on SCANS-III density estimate of 0.888/km²)		**696**	**214**
% of North Sea MU reference population (345,373 harbour porpoise)		**0.2%**	**0.06%**
% SNS cSAC (29,384 harbour porpoise)		**2.4%**	**0.7%**

5.3.4 OWF operation and maintenance

106. For operational OWFs within (wholly or partly) the SNS cSAC that could have potential in-combination effects during the Norfolk Vanguard construction period, the area of the OWF that overlaps the cSAC winter and summer areas has been estimated. Based on this 'potential worst-case' scenario, six OWFs located in the SNS cSAC could potentially have disturbance from operational OWFs and maintenance activities that overlap with construction of Norfolk Vanguard.

107. The in-combination assessment indicates that, the estimated maximum in-combination area of disturbance is 915km^2 (Table 15).

108. One of these OWFs is located in the summer cSAC area and the estimated maximum area of disturbance for the summer cSAC area is 52km^2, which represents approximately 0.2% of the summer cSAC area (Table 15).

109. Five of these OWFs are located in the winter cSAC area and the estimated maximum in-combination area of disturbance for the winter cSAC area is 482km^2, which represents approximately 4% of the winter cSAC area (Table 15).

110. However, based on the precautionary, but more realistic scenario that harbour porpoise could be disturbed from up to 50% of the offshore wind farm sites as a result of operation and maintenance activities, the estimated maximum in-combination area of disturbance is 457.5km^2 (Table 15).

Table 15 Quantified CIA for the potential disturbance of harbour porpoise (and % of reference population and % SNS cSAC) during operation and maintenance activities at OWFs in the SNS cSAC during construction at Norfolk Vanguard

Name of Project	Area of OWF site (km^2)*	SCANS-III density estimate (No/km^2)	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)	Potential number of harbour porpoise disturbed
Greater Gabbard	146	0.607	0	146	89
Scroby Sands	9	0.607	0	9	6
Thanet	35	0.607	0	9	6
Galloper	113	0.607	0	113	69
Hornsea Project One	407	0.888	52	0	46
East Anglia ONE	205	0.607	0	205	124
Total	**915**		**52**	**482**	**340**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.1%**
% SNS cSAC (29,384 harbour porpoise)					**1%**
50% disturbance	**457.5**		**26**	**241**	**170**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.05%**
% SNS cSAC (29,384 harbour porpoise)					**0.6%**

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

5.4 Overall cumulative underwater noise impacts (Impacts 1 and 2)

111. 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 Vanguard as the impact ranges for piling would be significantly greater than those impacts from other construction noise sources.

112. The worst-case assessment (Table 16) 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).

113. The precautionary, but more realistic scenario (Table 17) is based on up to 50% disturbance of harbour porpoise could be disturbed from offshore wind farm sites as a result of construction activities, other than piling, operational turbines, maintenance activities and vessels.

Table 16 Quantified CIA for the potential disturbance of all harbour porpoise in the North Sea MU and SNS cSAC summer and winter areas (and % of reference population and %SNS cSAC) from all possible noise sources during construction at Norfolk Vanguard based on worst-case scenario

Potential noise sources during piling at Norfolk Vanguard	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Piling at OWF projects, based on potential worst-case scenario of OWF projects that could be piling at the same time (Sofia, Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single pile installation at each site and average overlap with cSAC seasonal areas	4,268km^2	2,593km^2
OWF construction activities, based on OWFs that are not piling but potential for other construction activities during piling at Norfolk Vanguard and 100% disturbance	1,567km^2	482km^2
OWF operation and maintenance, based on constructed OWFs that could have O&M activities during piling at Norfolk Vanguard and 100% disturbance	52km^2	482km^2
Sub-total (without UXO clearance and seismic surveys)	***5,887km²***	***3,557km²***
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km²)	***5,228***	***3,159***
% of North Sea MU reference population (345,373 harbour porpoise)	***1.5%***	***0.9%***
% SNS cSAC (29,384 harbour porpoise)	***18%***	***11%***
UXO clearance, based on up two locations, one in each cSAC seasonal area	2,124km^2	2,124km^2
Seismic surveys, based on up two locations, one in each cSAC seasonal area	324km^2	324km^2
Total	**8,335km^2**	**6,005km^2**
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km²)	**7,402**	**5,332**
% of North Sea MU reference population (345,373 harbour porpoise)	**2%**	**1.5%**
% SNS cSAC (29,384 harbour porpoise)	**25%**	**18%**

Table 17 Quantified CIA for the potential disturbance of all harbour porpoise in the North Sea MU and SNS cSAC summer and winter areas (and % of reference population and %SNS cSAC) from all possible noise sources during construction at Norfolk Vanguard based on precautionary scenario

Potential noise sources during piling at Norfolk Vanguard	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Piling at OWF projects, based on potential worst-case scenario of OWF projects that could be piling at the same time (Sofia, Creyke Beck B, Hornsea Project Three, East Anglia TWO and Norfolk Vanguard West) for single pile installation at each site and average overlap with cSAC seasonal area	4,268km^2	2,593km^2
OWF construction activities, based on OWFs that are not piling but potential for other construction activities during piling at Norfolk Vanguard and 50% disturbance	783.5km^2	241km^2
OWF operation and maintenance, based on constructed OWFs that could have O&M activities during piling at Norfolk Vanguard and 50% disturbance	26km^2	241km^2
Sub-total (without UXO clearance and seismic surveys)	***5,078km²***	***3,075km²***
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km²)	***4,509***	***2,731***
% of North Sea MU reference population (345,373 harbour porpoise)	***1.3%***	***0.8%***
% SNS cSAC (29,384 harbour porpoise)	***15%***	***9.3%***
UXO clearance, based on up two locations, one in each cSAC seasonal area	2,124km^2	2,124km^2

Potential noise sources during piling at Norfolk Vanguard	Area in summer cSAC area (km^2)	Area in winter cSAC area (km^2)
Seismic surveys, based on up two locations, one in each cSAC seasonal area	324km^2	324km^2
Total	**7,526km^2**	**5,523km^2**
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km^2)	**6,683**	**4,904**
% of North Sea MU reference population (345,373 harbour porpoise)	**1.9%**	**1.4%**
% SNS cSAC (29,384 harbour porpoise)	**23%**	**17%**

5.5 Changes in prey availability

114. 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.

115. 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

116. The potential increased collision risk with vessels during the construction of OWFs 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 the number of animals that could be present in the wind farm areas taking into account 95% avoidance rates. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the wind farm areas would be at increased collision risk with vessels.

117. The number of harbour porpoise in the potential impact area has been determined using the latest SCANS-III density estimates (Hammond *et al.*, 2017) for the area of the projects, taking into account 95% avoidance rates.

Table 18 Quantified CIA for the potential increased collision risk with vessels for harbour porpoise during OWF construction

Name of Project	Tier	Distance to NV (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km^2)	Area of OWF site*	Potential number of harbour porpoise based on 95% avoidance
Norfolk Vanguard	5	0	O[1]	0.888	592	26
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
East Anglia THREE	3	0	L	0.607	301	9
Norfolk Boreas	5	30	O[3]	0.888	727	32
Hornsea Project 3	5	80	O	0.888	695	31
Thanet Extension	5	165	L	0.607	73	2
East Anglia ONE North	5	30	L	0.607	206	6
East Anglia TWO	5	45	L	0.607	255	8
Total						**214**
% of North Sea MU reference population (345,373 harbour porpoise)						**0.06%**
% SNS cSAC (29,384 harbour porpoise)						**0.7%**

[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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