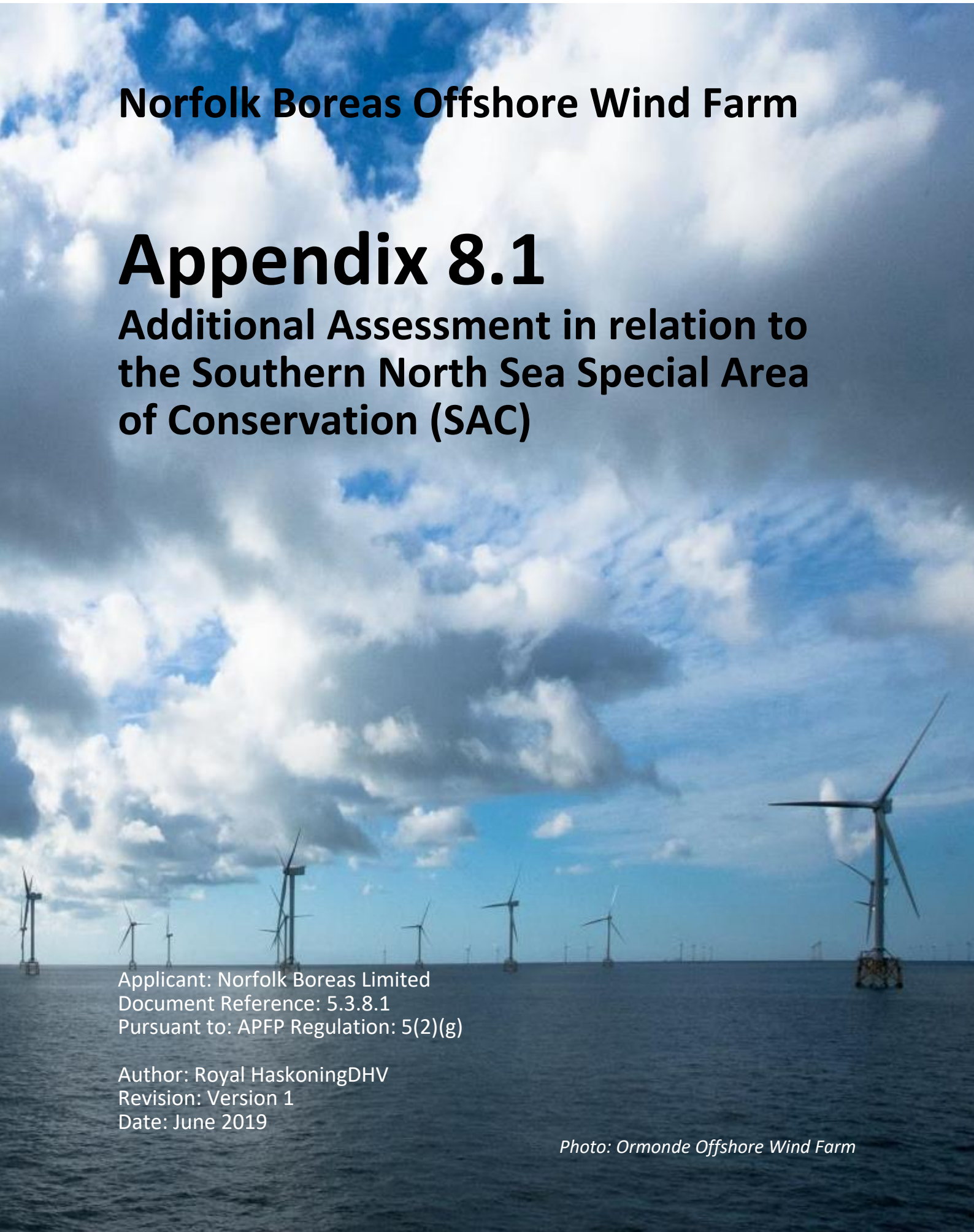
Norfolk Boreas Offshore Wind Farm

Appendix 8.1

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



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Author: Royal HaskoningDHV
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Glossary of Acronyms

CI	Confidence Interval
CV	Confidence Variation
dB	Decibels
DWR	Deep Water Route
EPS	European Protected Species
ES	Environmental Statement
ETG	Expert Topic Group
HP	Harbour porpoise
HRA	Habitats Regulations Assessment
JNCC	Joint Nature and Conservation Committee
km	Kilometre
m	Metre
km^2	Kilometre squared
MMMP	Marine Mammal Mitigation Protocol
MU	Management Unit
NE	Natural England
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
NS	North Sea
O&M	Operation and Maintenance
OWF	Offshore Wind Farm
PTS	Permanent Threshold Shift
SCANS	Small Cetaceans in the European Atlantic and North Sea
SEL	Sound Exposure Level
SNCB	Statutory Nature Conservation Body
SNS	Southern North Sea
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
UK	United Kingdom
UXO	Unexploded Ordnance

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Landfall	Where the offshore cables come ashore at Happisburgh South
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.
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 power 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.
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 OWF 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.

1 INTRODUCTION

1.1 Purpose of this Document

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

2. The Norfolk Boreas site lies within the SNS SAC with a small segment on the north-eastern corner being outside of the site (see Figure 5.3 of the Information for the Habitats Regulations Assessment). Norfolk Boreas is located within the SNS SAC summer area, the project interconnector area is located in the SNS SAC summer area and offshore cable corridor crosses summer and winter areas.

3. The SNS cSAC Site Selection Report (JNCC, 2017a) identifies that the SNS cSAC 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 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 (Coefficient of Variation (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 Information for the Habitats Regulations Assessment. However, it was agreed with the marine mammal Expert Topic Group (ETG) at the meeting on 15th February 2017 that the estimate of the number of harbour porpoise that the SNS SAC could support based on 17.5% of the UK North Sea MU would be assessed in a separate appendix for information.

5. Therefore, for information purposes, this Appendix presents an assessment on the estimated number of harbour porpoise that the SNS SAC site could support a total 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 EFFECTS DURING CONSTRUCTION

2.1 Underwater noise during Unexploded Ordnance clearance

2.1.1 Permanent auditory injury

6. 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 (NE) advice (20180209 NE position on National Oceanographic and Atmospheric Association (NOAA) Unexploded Ordnance (UXO)s and European Protected Species (EPS)) the assessment has been based on the worst-case scenarios for the unweighted SPL_{peak} predicted Permanent Threshold Shift (PTS) impact ranges. The estimated number of harbour porpoise that could be at risk of PTS or TTS during UXO clearance at Norfolk Boreas is presented in Table 1.

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 3km compared to real data). Therefore, as a precautionary approach, it is considered that the maximum potential impact range for PTS is likely to be 5km.

8. A Marine Mammal Mitigation Plan (MMMP) for UXO clearance will be produced post-consent in consultation with the MMO and relevant Statutory Nature Conservation Bodies (SNCBs) and will be based on the latest scientific understanding and guidance, pre-construction UXO surveys at the Norfolk Boreas 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 effect 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	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
Weighted (NMFS, 2018)								
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

2.1.2 Disturbance

9. 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 SNS SAC.

10. The estimated number of harbour porpoise that could be disturbed during UXO clearance at Norfolk Boreas is presented in Table 2. Only one UXO would be detonated at a time during UXO clearance operation at Norfolk Boreas; there would be no concurrent UXO detonations.

Table 2: Estimated number of harbour porpoise potentially disturbed during UXO clearance

Potential Effect	Estimated number in 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).	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.

11. The assessment indicates that less than 1% of the North Sea MU reference population (approximately 7.7% of the number of harbour porpoise that the SNS SAC

could potentially support) could be temporarily displaced during UXO clearance at Norfolk Boreas (alone), based on the worst-case scenario.

2.2 Underwater noise during piling

2.2.1 Disturbance during proposed mitigation

12. The number of harbour porpoise that could potentially be disturbed as a result of the proposed mitigation would be up to 43 individuals (0.013% of the NS MU reference population; 0.15% SNS SAC), based on the site specific density (1.06 harbour porpoise per km^2) as a worst-case scenario.

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

2.2.2 Disturbance during single pile installation

14. The estimated number of harbour porpoise that could be disturbed during single pile installation at Norfolk Boreas is presented in Table 3.

Table 3: Estimated number of harbour porpoise potentially disturbed during piling based on 26km range from a single piling location at Norfolk Boreas

Potential Effect	Estimated number in area[1]	% of reference population[1]
Area of disturbance (2,124km^2) from underwater noise during single pile installation	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).	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.

15. The assessment indicates that 0.65% or less of the North Sea MU reference population (approximately 7.7% of the number of harbour porpoise that the SNS SAC could potentially support) could be temporarily displaced during any single pile installation at Norfolk Boreas (alone), based on the worst-case scenario.

2.2.3 Disturbance during concurrent piling

16. The estimated number of harbour porpoise that could be disturbed during concurrent pile installation at Norfolk Boreas is presented in Table 4 based on the maximum disturbance areas.

Table 4: Estimated number of harbour porpoise potentially disturbed during concurrent piling based on 26km range from each piling location

Potential Effect	Estimated number in area[1]	% of reference population[1]
Two concurrent piling events in the Norfolk Boreas site (4,146km^2)	3,682.5 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 4,395 harbour porpoise based on site specific survey density (1.06/km^2).	1.1% of 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.

17. The assessment indicates that up to a maximum of 1.3% of the North Sea MU reference population (approximately 15% of the number of harbour porpoise that the SNS SAC could potentially support) could be temporarily disturbed during concurrent piling at Norfolk Boreas (alone), based on the worst-case scenario.

2.3 Underwater noise during other construction activities

18. 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.

19. 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.

20. 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 619 harbour porpoise (0.2% of the North Sea MU reference population; 2.1% SNS SAC) could be temporarily displaced.

Table 5: Estimated number of harbour porpoise (and % of reference population; % SNS SAC) that could be present in the Norfolk Boreas offshore area (wind farm sites and cable corridor)

Potential Area	Estimated number in area	% of reference population (% SNS SAC)
Norfolk Boreas site (725km^2)	644 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 769 harbour porpoise based on site specific survey density (1.06/km^2).	0.19% of NS MU (2.2% SNS SAC) based on SCANS-III density. 0.2% of NS MU (2.6% SNS SAC) based on site specific survey density.
Project Interconnector Search Area in NV West (120.6km^2)	107 harbour porpoise based on SCANS-III survey block O density (0.888/km^2).	0.03% of NS MU (0.4% SNS SAC) based on SCANS-III density.

Potential Area	Estimated number in area	% of reference population (% SNS SAC)
	95 harbour porpoise based on site specific survey density (0.79/km^2) at NV West.	0.03% of NS MU (0.3% SNS SAC) based on site specific survey density at NV West.
Project Interconnector Search Area in NV East (106.4km^2)	95 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 134 harbour porpoise based on site specific survey density (1.26/km^2) at NV East.	0.03% of NS MU (0.3% SNS SAC) based on SCANS-III density. 0.04% of NS MU (0.5% SNS SAC) based on site specific survey density at NV East.
Offshore cable corridor (226km^2)	201 harbour porpoise based on SCANS-III survey block O density (0.888/km^2). 240 harbour porpoise based on site specific survey density (1.06/km^2).	0.06% of NS MU (0.7% SNS SAC) based on SCANS-III density. 0.07% of NS MU (0.8% SNS SAC) based on site specific survey density.
Total offshore project area (1,178km^2)	1,046 harbour porpoise based on SCANS-III survey block O density. 1,238 harbour porpoise based on site specific survey densities for Norfolk Boreas, NV East and NV West.	0.3% of NS MU (3.6% SNS SAC) based on SCANS-III density. 0.4% of NS MU (4.2% SNS SAC) based on site specific survey density.

2.4 Underwater noise and disturbance from vessels

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

22. Underwater noise generated by vessels would only be sufficient to cause PTS to harbour porpoise if an individual remained within 100m of the vessel for a period of 24 hours, which is highly unlikely. The number of harbour porpoise the could be at risk of PTS from SEL_{cum} from vessel noise (using the area of a circle around the impact range) is 0.03 (0.00001% of the North Sea MU; 0.0001% of the SNS SAC), based on the site specific density of 1.06/km^2.

23. 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 effects seems to be approximately 20,000 ships per year (approximately 80 vessels per day within a 5km^2 area).

24. Chapter 15 Shipping and Navigation of the Environmental Statement (ES) provides a description of the baseline conditions and anticipated additional ship movements arising from the construction and operation of the proposed project.

25. Throughout the summer period of the marine traffic survey, there was on average 66 unique vessels per day recorded within the Norfolk Boreas site, 106 unique vessels per day recorded within the offshore cable corridor and on average 20 unique vessels per day recorded within the project interconnector search areas. Throughout the winter period of the marine traffic survey, there was on average 36 unique vessels per day recorded within the Norfolk Boreas site, 93 unique vessels per day recorded within the offshore cable corridor and on average 15 unique vessels per day recorded within the project interconnector search areas. The majority of vessels recorded were cargo vessels and tankers, with most of these vessels utilising the IMO Routeing Measures in the area; however other main routes were identified out with the Deep Water Routes (DWR), including routes which intersected the Norfolk Boreas site.

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 30% increase in the number of vessels during the summer period and 40% 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 (1,178km^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 Boreas area, but taking into account that other vessels would be restricted from entering the immediate construction site (with a 500m safety zone around construction vessels and partially installed foundations), the number of vessels would be unlikely to exceed the Heinänen and Skov (2015) threshold level of 80 vessels per day in a 5km^2 area. Therefore, there is unlikely to be the potential for significant disturbance to harbour porpoise as a result of the increased number of vessels during construction.

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 5). 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 619 harbour porpoise (0.2% of the North Sea MU reference population; 2.1% SNS SAC) could be temporarily displaced.

2.5 Vessel collision risk

31. During the construction of Norfolk Boreas 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.

32. For Norfolk Boreas, 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.

33. The construction port to be used for Norfolk Boreas 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 Boreas are estimated to be an average of two per day.

34. 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 (Table 6).

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

36. 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.

37. In addition, based on the assumption that harbour porpoise would be disturbed from a 26km radius during piling and disturbed from the Norfolk Boreas 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 Boreas during the construction period.

Table 6: Estimated number of harbour porpoise that could be present in the Norfolk Boreas offshore area (wind farm sites and cable corridor) at potential increased collision risk based on 95-90% avoidance

Potential Area	Estimated number at potential increased collision risk based on 95-90% avoidance	% of reference population (% SNS SAC)
Total offshore project area (1,178km^2)	52-105 harbour porpoise based on SCANS-III survey block O density. 62-125 harbour porpoise based on site specific survey density.	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 Changes to prey resource

38. As a precautionary worse-case scenario, the number of harbour porpoise that could be affected 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 5). 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.

39. 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 619 harbour porpoise (0.2% of the North Sea MU reference population; 2.1% SNS SAC) being temporarily displaced.

40. 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.

3 POTENTIAL EFFECTS DURING OPERATION

41. 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 Underwater noise from operational turbines

42. 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).

43. 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 Norfolk Boreas site (Table 7). 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.

44. 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 7).

Table 7: Estimated number of harbour porpoise (and % of reference population and % SNS SAC) that could be disturbed from the Norfolk Boreas site during operation based on 100%, 50% and 0% disturbance as a result of operational turbine noise

Potential Area	Estimated number in potential area			% of reference population (% SNS SAC)		
	100%	50%	0%	100%	50%	0%
Total offshore wind farm area (725km^2)	644 based on SCANS-III density (0.888/km^2). 769 based on site specific survey density (1.06/km^2).	322 based on SCANS-III density (0.888/km^2). 385 based on site specific survey density (1.06/km^2).	0	0.2% of NS MU (2.2% SNS SAC) based on SCANS-III density. 0.2% of NS MU (2.6% SNS SAC) based on densities at each site.	0.09% of NS MU (1.1% SNS SAC) based on SCANS-III density. 0.1% of NS MU (1.3% SNS SAC) based on densities at each site.	0

3.2 Underwater noise from maintenance activities

45. 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 effects would be less than those during construction.

46. 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 5).

47. 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 Vessel underwater noise and disturbance during operation and maintenance

48. 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.

49. 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 5).

50. The potential effects 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 Vessel collision risk

51. 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.

52. 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 6).

53. This is very precautionary, as it is highly unlikely that all harbour porpoise present in the Norfolk Boreas 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 Changes to prey resource during operation and maintenance

54. As a precautionary worst-case scenario approach the number of harbour porpoise that could be affected 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 5). 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 EFFECTS DURING DECOMMISSIONING

55. 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 Underwater noise from foundation removal

56. 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.

57. For this assessment it is assumed that the potential effects from underwater noise during decommissioning would be no greater than those assessed for piling and comparable to those assessed for other construction activities.

4.2 Vessel underwater noise and disturbance from vessels

58. For this assessment it is assumed that the potential effects no greater than during construction.

4.3 Vessel collision risk

59. For this assessment it is assumed that the potential effects would be no greater than during construction.

4.4 Changes to prey resource

60. For this assessment it is assumed that the potential effects would be no greater than during construction.

5 IN-COMBINATION EFFECTS

5.1 Approach

61. The approach to this in-combination assessment differs from that taken in the Habitats Regulation Assessment (HRA) in terms of geographic range. If this assessment is based upon the number of harbour porpoise that the SNS SAC could potentially support than it follows that the effects must be limited to those occurring within the SNS SAC boundary, if the effects outside the boundary are included (as per the HRA) then the population used for the assessment must reflect that (i.e. the NS MU population as per the HRA).

5.2 Underwater noise effects during construction from Offshore Wind Farm piling

62. 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 in-combination assessment.

63. Following the current advice from the SNCBs, the in-combination assessment 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.

64. 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.

65. The potential disturbance from Offshore Wind Farms (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.

66. 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.

67. Where a quantitative assessment has been possible, the potential magnitude of disturbance in the in-combination assessment has been based on the number of harbour porpoise in the potential area using the latest SCANS-III density estimates (Hammond et al., 2017) for the area of the projects.

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

- Creyke Beck A
- Teesside A
- Hornsea Project Three
- East Anglia ONE North

69. 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.

70. 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.

71. 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 SAC (Table 8). 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 8: Estimated maximum, minimum and average overlap with SNS SAC winter and summer areas and number of harbour porpoise (% of reference population and % SNS SAC) for potential worst-case scenarios (Teesside A, Creyke Beck 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 OWFs) – 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 OWFs) – 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 Underwater noise effects from all other noise sources

5.3.1 UXO clearance

72. 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 in-combination effects for lethal injury, physical injury and permanent auditory injury (PTS), therefore the in-combination assessment only considers potential disturbance effects.

73. 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 Boreas.

74. 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.

75. Following the current SNCB advice, the in-combination assessment 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.

76. 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.

77. 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.

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) (Table 9).

79. 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 9: Quantified in-combination assessment for the potential disturbance of harbour porpoise (and % of reference population and % SNS SAC) 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
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

80. 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.

81. 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 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.

82. Following the current SNCB advice, the in-combination assessment 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).

83. It should be noted that this assessment is based on the potential effects 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.

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

85. 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) (Table 10).

86. 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 10: Quantified in-combination assessment 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
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

87. During the construction of Norfolk Boreas, there is the potential overlap with effects from the construction activities, other than piling, of OWF.

88. There would be no additional in-combination effects 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.

89. 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 in-combination effects from construction of OWFs in and around the area of Norfolk Boreas.

90. The in-combination assessment includes OWFs in the SNS SAC which could potentially have construction activities, other than piling, during the Norfolk Boreas construction period.

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

- Creyke Beck B;
- Sofia;
- East Anglia TWO;
- Thanet Extension;
- Norfolk Vanguard; and
- Hornsea Project Four.

92. 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.

93. In addition, it is likely, as outlined for the in-combination assessment for piling, that developers of more than one site will only 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.

94. 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 (Table 11).

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

96. 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 number of harbour porpoise that could be disturbed is 2,100 (less than 1% of the North Sea MU and 7.1 of the SNS SAC).

Table 11: Quantified in-combination assessment for the potential disturbance of harbour porpoise during construction activities (other than piling) at OWFs in the SNS SAC during construction at Norfolk Boreas

Name of Project	Area of OWF site (km^2)*	SCANS-III density estimate (No/km^2)	Area in summer SAC area (km^2)	Area in winter SAC area (km^2)	Potential number of harbour porpoise disturbed
Creyke Beck B	599	0.888	599	0	532
Sofia	593	0.888	132	0	117
East Anglia TWO	255	0.607	0	255	155
Thanet Extension	73	0.607	0	31	19
Norfolk Vanguard	592	0.888	592	1	526
Hornsea Project Four	846	0.888	846	0	751
Total	**2,958**	**-**	**2,169**	**287**	**2,100**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.6%**
% SNS SAC (29,384 harbour porpoise)					**7.1%**

5.3.4 OWF operation and maintenance

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

98. The in-combination assessment indicates that, the estimated maximum in-combination area of disturbance is 1,488km^2 (Table 12).

99. Three of these OWFs are located in 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 12).

100. Three of these OWFs are located in 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 12).

Table 12: Quantified CIA for the potential disturbance of harbour porpoise (and % of reference population and % SNS SAC) during operation and maintenance activities at OWFs in the SNS SAC during construction at Norfolk Boreas

Name of Project	Area of OWF site (km^2)*	SCANS-III density estimate (No/km^2)	Area in summer SAC area (km^2)	Area in winter SAC area (km^2)	Potential number of harbour porpoise disturbed
Galloper	113	0.607	0	113	69
Hornsea Project One	407	0.888	50	0	44
Hornsea Project Two	462	0.888	298	0	265
East Anglia ONE	205	0.607	0	205	124
East Anglia THREE	301	0.607	301	203	183
Total	**1,488**	-	**649**	**521**	**685**
% of North Sea MU reference population (345,373 harbour porpoise)					**0.2%**
% SNS SAC (29,384 harbour porpoise)					**2.3%**

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

5.4 Overall in-combination underwater noise effects

101. This section considers the overall in-combination effects of underwater noise associated with piling and all other noise sources. There would be no additional in-combination effects 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 from other construction noise sources.

102. The worst-case assessment (Table 13) 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 effects listed).

Table 13: Quantified in-combination assessment for the potential disturbance of all harbour porpoise in the North Sea MU and SNS SAC summer and winter areas (and % of reference population and % SNS SAC) from all possible noise sources during construction at Norfolk Boreas based on worst-case scenario

Potential noise sources during piling at Norfolk Boreas	Area in summer SAC area (km^2)	Area in winter SAC area (km^2)
Piling at OWF projects, based on potential worst-case scenario of OWF projects that could be piling at the same time (Teesside A, Creyke Beck A, Hornsea Project Three, East Anglia ONE North and Norfolk Boreas) for single pile installation at each site and average overlap with SAC seasonal areas	3,958km^2	2,259km^2
OWF construction activities, based on OWFs that are not piling but potential for other construction activities during piling at Norfolk Boreas and 100% disturbance	2,169km^2	287km^2
OWF operation and maintenance, based on constructed OWFs that could have O&M activities during piling at Norfolk Boreas and 100% disturbance	649km^2	521km^2
Sub-total (without UXO clearance and seismic surveys)	***6,776km^2***	***3,067km^2***
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km^2)	***6,017***	***2,723***
% of North Sea MU reference population (345,373 harbour porpoise)	***1.7%***	***0.8%***
% SNS SAC (29,384 harbour porpoise)	***20.5%***	***9.3%***
UXO clearance, based on up two locations, one in each SAC seasonal area	2,124km^2	2,124km^2
Seismic surveys, based on up two locations, one in each SAC seasonal area	314km^2	314km^2
Total	**9,214km^2**	**5,505km^2**
Number of harbour porpoise (based on SCANS-III density estimate of 0.888/km^2)	**8,182**	**4,888**
% of North Sea MU reference population (345,373 harbour porpoise)	**2.4%**	**1.4%**
% SNS SAC (29,384 harbour porpoise)	**27.8%**	**16.6%**

5.5 Changes in prey availability

103. The in-combination assessment for potential changes to prey availability has assumed that any potential effects 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 effects 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.

104. Any effects 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

105. 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.

106. The number of harbour porpoise in the potential 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 14: Quantified in-combination assessment for the potential increased collision risk with vessels for harbour porpoise during OWF construction

Name of Project	Tier	Distance to NB (km)	SCANS-III Survey Block	SCANS-III density estimate (No/km²)	Area of OWF site*	Potential number of harbour porpoise based on 95% avoidance
Norfolk Boreas	5	0	O[1]	0.888	727	32
Creyke Beck A	3	173	O	0.888	515	22
Creyke Beck B	3	196	O	0.888	599	27
Teesside A	3	191	N	0.837	562	24
Sofia	3	185	O[3]	0.888	593	26
Norfolk Vanguard	4	30	O[4]	0.888	592	26
Hornsea Project Three	4	53	O	0.888	695	31
Thanet Extension	4	175	L	0.607	73	2
East Anglia ONE North	5	51	L	0.607	206	6
East Anglia TWO	5	73	L	0.607	255	8
Hornsea Project Four	5	119	O	0.888	846	38
Total						**242**
% of North Sea MU reference population (345,373 harbour porpoise)						**0.07%**
% SNS c SAC (29,384 harbour porpoise)						**0.8%**

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

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