Norfolk Vanguard Offshore Wind Farm

Consultation Report

Appendix 9.13 Marine Mammals Outgoing Documents

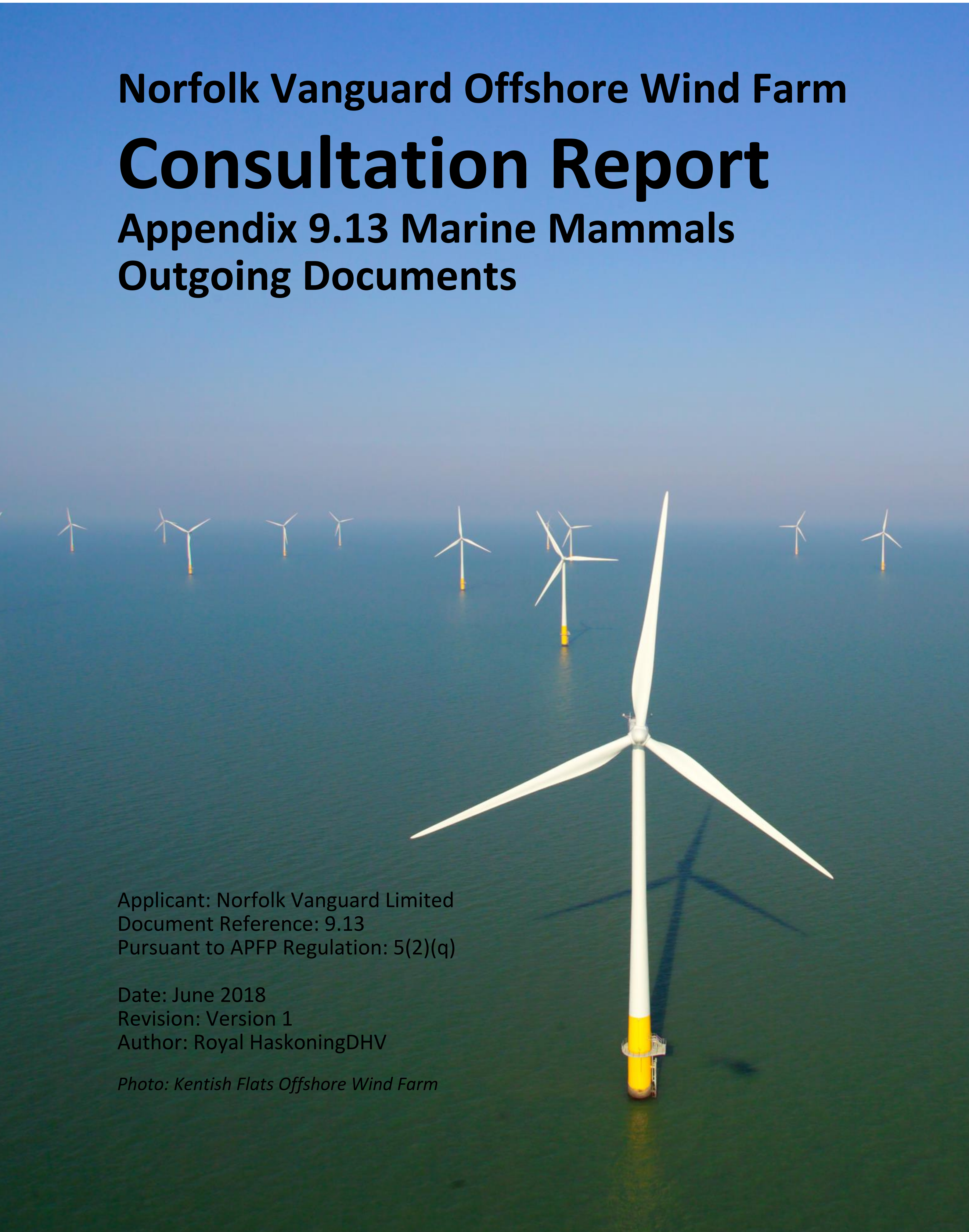

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Photo: Kentish Flats Offshore Wind Farm

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Norfolk Vanguard Offshore Wind Farm

Environmental Impact Assessment

Marine Mammals Method Statement

Document Reference: PB4476-003-036

Author: Royal HaskoningDHV
Date: February 2017
Client: Vattenfall Wind Power Ltd

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
26/01/17	00	Internal Review	GK/ Gemma Starmore	Jen Learmonth	AD
30/01/17	01	Issue for Vattenfall Review	GK	JL	AD
01/02/17	02	Issue for Topic Group Review	GK	KW	KW

This method statement has been prepared by Royal HaskoningDHV on behalf of Vattenfall Wind Power Limited (VWPL) in order to build upon the information provided within the Norfolk Vanguard Environmental Impact Assessment (EIA) Scoping Report. It has been produced following a full review of the Scoping Opinion provided by the Planning Inspectorate. All content and material within this document is draft for stakeholder consultation purposes, within the Evidence Plan Process.

Table of Contents

1 INTRODUCTION

1. The purpose of this method statement is to build upon the information provided within the Norfolk Vanguard Environmental Impact Assessment (EIA) Scoping Report, in outlining the proposed approach to be taken and considerations to be made in the assessment of marine mammal effects of the proposed development. Indicative project information is provided, where possible to inform the method statement and consultation. These may be subject to change as the EIA progresses.

2. This marine mammal method statement has been produced following a full review of the Scoping Opinion provided by the Planning Inspectorate.

3. The approach outlined in this method statement also takes account of previous correspondence with Natural England, the Marine Management Organisation (MMO) and Cefas, including:

- Introduction meeting between Vattenfall Wind Power Limited (VWPL) and the MMO 14th January 2016;
- Meeting with Natural England and the MMO to discuss aerial survey scope 21st March 2016;
- Natural England Review of Geophysical and Grab Sampling Impact Assessment on the Southern North Sea proposed Special Area of Conservation (pSAC) 20th April 2016.

1.1 Background

4. A Scoping Report for the Norfolk Vanguard Environmental Impact Assessment (EIA) was submitted to the Planning Inspectorate on the 3rd October 2016. Further background information on the project can be found in the Scoping Report which is available at:

https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-000022-Scoping%20Report.pdf

5. The Scoping Opinion was received on the 11th November 2016 and can be found at:

https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-000018-Scoping%20Opinion.pdf.

1.2 Norfolk Vanguard Programme

1.2.1 DCO Programme

- Scoping Request submission - 03/10/16 (complete)

* Preliminary Environmental Information submission - Q4 2017
* Environmental Statement and DCO submission - Q2 2018

1.2.2 Evidence Plan Process Programme

6. The Evidence Plan Terms of Reference provides an overview of the Evidence Plan Process and expected logistics, below is a summary of anticipated meetings:

* Steering Group meeting 21/03/16 (complete)
* Steering Group meeting - 20/09/16 (complete)
* Post-scoping Expert Topic Group meetings
    * Discuss method statements and Project Design Statement - Q1 2017
* Expert Topic Group and Steering Group meetings as required - 2017
    * To be determined by the relevant groups based on issues raised
* PEIR Expert Topic Group and Steering Group meetings - Q4 2017/
    * To discuss the findings of the PEI (before or after submission) - Q1 2018
* Pre-submission Expert Topic Group and Steering Group meetings - Q1/Q2 2018
    * To discuss updates to the PEIR prior to submission of the ES

1.2.3 Survey Programme

1.2.3.1 Aerial survey

7. The following monthly aerial surveys have been undertaken of the Norfolk Vanguard site to characterise the site for ornithology and marine mammals (see Section 3.1):

* APEM aerial survey data of the former East Anglia FOUR site (now NV East) with 4km buffer between March 2012 and February 2014;
* APEM aerial survey data of NV East with 4km buffer from September 2015 to April 2016 (end date as agreed with Natural England); and
* APEM aerial survey data of NV West with 4km buffer ongoing since September 2015 (end date to be agreed with stakeholders).

2 PROJECT DESCRIPTION

2.1 Site Selection Updates

8. Further to the site selection information provided within the Norfolk Vanguard Scoping Report (Royal HaskoningDHV, 2016), additional site selection work has been undertaken to refine the locations of the onshore infrastructure. Offshore, the boundaries of the site and offshore cable corridor are the same as those already presented in the Scoping Report. The Norfolk Vanguard EIA Scoping Report identified search areas for the onshore infrastructure, including a landfall search area. Further data review has been undertaken to understand the engineering and environmental constraints within this search areas identified. Public drop-in-exhibitions in October 2016 and the Scoping Opinion have also contributed to our broader understanding of local constraints and opportunities.

9. Information provided in this Method Statement is a draft for stakeholder consultation only and is provided in confidence. Equivalent information will be presented during open drop-in-exhibitions in March 2017, providing an opportunity for local people and the wider public to understand the way in which their feedback, as well as the Scoping Opinion, has influenced our design. Given the broad range and complexity of the factors influencing onshore site selection, including landfall, and the scale of the area under discussion, it is our intention that local people and interested parties view the map for the first time, with Vattenfall and suitably qualified experts on hand. This enables a meaningful discussion of the proposed options and enables participants to refer directly to points of reference they may wish to discuss. During the March drop-in exhibitions, participants will also be invited to provide feedback on the latest design.

2.1.1 Landfall Zones

10. The landfall search area was presented in the Scoping Report as Figure 1.3. Following studies on the engineering feasibility of horizontal directional drilling (HDD), this has been refined to three landfalls options; Bacton Green, Walcott Gap and Happisburgh South (Figure 1).

11. Ongoing public and stakeholder consultation as well as initial EIA data collection will be used to inform selection of final locations for the EIA and DCO application, with the aim to further avoid sensitive areas. Impacts that cannot be avoided through site selection will aim to be reduced through sensitive siting, alternative engineering solutions (mitigation by design) and additional mitigation measures, where possible. Mitigation options will be developed in consultation with stakeholders.

2.1.2 Offshore Project Area

12. The offshore project area remains unchanged from that presented in the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016a) and consists of:

- The offshore cable corridor;
- Norfolk Vanguard West (NV West); and
- Norfolk Vanguard East (NV East).

2.2 Indicative Worst Case Scenarios

13. The following sections set out the indicative worst case scenarios for marine mammals. The PEIR/ES will provide a detailed Project Description describing the final Rochdale Envelope for the Norfolk Vanguard DCO application. Each chapter of the PEIR/ES will define the worst case scenario arising from the construction, operation and decommissioning phases of the Norfolk Vanguard project for the relevant receptors and impacts. Additionally, each chapter will consider separately the anticipated cumulative impacts of Norfolk Vanguard with other relevant projects on the receptors under consideration.

14. The following sections provide an overview of the key elements of the proposed development that are of relevance to marine mammals. Section 2.2.9 provides a summary of the indicative worst case scenario for marine mammals.

2.2.1 Wind Turbine Generators

2.2.1.1 Capacity

15. A range of 7MW to 20MW wind turbines is included in the Norfolk Vanguard Rochdale Envelope in order to future proof the EIA and DCO to accommodate foreseeable advances in technology.

2.2.1.2 Number of Turbines

16. It is assumed that turbines of 15MW to 20MW will have the same physical parameters (as it is expected that developments in efficiency will increase the MW capacity rather than increases in physical size). As a result, if the worst case scenario is associated with the largest turbines, 120 x 15MW will be the worst case scenario (rather than 90 x 20MW) due the greater number of devices making up the maximum site capacity of 1800MW. The maximum number of wind turbines will be 257 x 7MW.

2.2.1.3 Foundation Types

17. A range of foundation options; jacket, gravity base, suction caisson, monopile and floating foundations will be included in the Rochdale Envelope.

18. Monopiles and pin piles will be driven, drilled or drilled-driven into the seabed. It is estimated up to 50% of the locations could need drilling if these foundation options are chosen.

19. Table 2.1 outlines the indicative maximum hammer energies required for the largest and smallest pile size options. The underwater noise modelling will also consider the soft-start starting energies.

Table 2.1 Indicative maximum piling hammer energies

Maximum hammer energy	7MW pin pile (3m diameter)	15-20MW pin pile (5m diameter)	7MW monopile (8.5m diameter)	15-20MW monopile (10m diameter)
Maximum hammer energy (kJ)	2700	2700	4000	5000
Starting energy (kJ)	TBC	TBC	TBC	TBC

20. Further to the information provided in the Scoping Report, floating foundations will be included in the Norfolk Vanguard Rochdale Envelope. Ongoing review by the VWPL engineering team has identified that this is necessary in order to future proof the EIA and DCO to include the types of foundations that are likely to be available by the time of Norfolk Vanguard construction, potentially starting in 2023. Parameters of the floating foundations are currently being reviewed by the VWPL engineering team and will be available for the EIA and DCO application. The following aspects will be considered in order to assess the impact during construction of floating foundations on marine mammals (O&M parameters are outlined in Section 2.2.7):

- Anchor options, e.g.:
  - Suction caisson;
  - Piled;
  - Drag anchor;
  - Gravity base with tension cables (Tension Leg Platform (TLP));
- Number of anchors required per turbine.

21. The seabed footprint of the turbines will be considered in relation to potential changes to prey resource and water quality. The worst case scenarios associated with these are provided in the Fish and Shellfish Ecology Method Statement and the Marine Water and Sediment Quality Method Statement.

2.2.1.4 Layout

22. The layout of wind turbines will be determined pre-construction based on post consent site investigation works and detailed design works. The minimum spacing will be four times the turbine diameter (616m based on the minimum diameter of

154m) and the maximum spacing will be 15 times the turbine diameter (4.5km based on the maximum diameter of 303m).

23. The maximum capacity that may be located in NV West is estimated to be 1800MW (i.e. 100% of the turbines) and the maximum capacity in NV East is estimated to be 1200MW (i.e. 67% of the turbines) with the remaining 600MW in NV West. Consideration will be given to the worst case location for marine mammals, which may either be:

- A 50:50 split between NV East and NV West with the maximum spacing to provide the maximum spatial extent of potential impacts on marine mammals; or
- The maximum number of turbines in the site which has the greatest density of marine mammals (subject to the available density estimates (see Section 3.3)).

2.2.2 Offshore Cabling

24. Two electrical solutions are being considered for Norfolk Vanguard, a High Voltage Alternating Current (HVAC) and a High Voltage Direct Current (HVDC) scheme. The decision as to which option will be used for the project will be agreed post consent and will depend on availability, technical considerations and cost. Both electrical solutions will have implications on the required offshore infrastructure. The key indicative offshore cabling parameters are as follows:

- Number of cables;
  - 6 subsea HVAC export cables or 4 subsea HVDC export cables;
  - 2 subsea HVAC interconnector systems[1], linking the three offshore substations (see Section 26) or 1 HVDC subsea interconnector system[2], linking the two offshore converter stations (see Section 2.2.3);
  - Inter-array cabling - subject to number of turbines and layout;
- Export cable length per cable (from substation/convertor station to landfall);
  - NV East - approximately 110km for HVAC and HVDC;
  - NV West - approximately 100km for HVAC and HVDC;
- Maximum export cable length;
  - 640km based on six HVAC cables;
- Interconnector cable length up to 50km per system for HVAC and HVDC options
- Inter-array cable length up to 515km;

25. The preferred construction technique and depth of burial for the offshore electrical infrastructure will be decided pre-construction based on ground investigation. Possible installation techniques include:

[1] 1 cable.
[2] Up to 3 cables in up to 2 trenches.

- Ploughing;
- Jetting;
- Dredging;
- Mass flow excavation[3]; and
- Trenching.

26. In some cases, cable burial cannot be undertaken and surface laying with cable protection will be required. In addition to this, it is estimated that up to 50m of cable may be surface laid on approach to the wind turbines or substation/convertor station platforms.

2.2.3 Ancillary Infrastructure

2.2.3.1 Offshore substation/convertor station platforms

27. Up to three substation platforms (HVAC) or two convertor station platforms (HVDC) will be required. Foundation options are:

- Piled monopile (10m diameter);
- Suction caisson monopile (20m diameter);
- Piled tripod (3m diameter pile x 3);
- Suction caisson tripod (3m diameter caisson x 3);
- Piled quadropod (3m diameter pile x 4);
- Suction caisson quadropod (3m diameter caisson x 4).

28. The seabed footprint of ancillary infrastructure will be considered in relation to potential changes to prey resource and water quality. The worst case scenarios associated with these are provided in the Fish and Shellfish Ecology Method Statement and the Marine Water and Sediment Quality Method Statement.

2.2.3.2 Accommodation platforms

29. A single accommodation platform may be required. Foundation options are as described in Section 2.2.3.1).

2.2.3.3 Met Masts

30. Up to 2 operational meteorological masts (met masts) may be installed within Norfolk Vanguard. Foundation options are:

- Jacket with pin piles;
- Jacket with suction caissons;
- Gravity Base;
- Suction caisson monopile; and

[3] An example of a mass flow excavator is available at http://www.rotech.co.uk/subsea/

- Piled Monopile.

31. In addition two LiDAR buoys and two wave buoys may be required.

2.2.4 Construction Vessels

32. Indicative vessel numbers that may be on site at one time for construction of a 600MW Phase or for 1800MW installed in one phase (further information on Phasing in Section 2.2.6.1) are provided in Table 2.2. These numbers are based on all activities occurring concurrently which is unlikely but provides a conservative worst case scenario. The PEIR/ES will also provide estimated vessel movements.

33. There may be up to two piling vessels operating concurrently in NV East and NV West, resulting in up to four vessels operating concurrently across the whole of Norfolk Vanguard.

Table 2.2 Indicative Vessel numbers on site at one time

Vessel Type	Maximum for single 600MW Phase	Maximum for 1800MW installed in 1 phase	Average for single 600MW Phase	Average for 1800MW installed in 1 phase
Seabed preparation vessels	5	9	2	5
Transition piece installation vessels	1	3	1	3
Scour Installation Vessels	5	9	3	5
Number of vessels engaged in foundations	10	30	10	15
WTG installation vessels	6	18	4	6
Commissioning vessels	6	15	4	6
Accommodation vessels	1	2	1	2
Inter-array cable laying vessels	3	7	2	3
Export cable laying vessels	4	12	4	12
Landfall cable installation vessels	2	2	2	2
Substation / collector station installation vessels	2	6	2	6
Other vessels	2	6	2	6
Total	**47**	**119**	**37**	**71**

2.2.5 Landfall

34. As discussed in Section 2.1.1, there are three potential landfall locations for Norfolk Vanguard:

- Bacton Green;

- Walcott Gap; and
- Happisburgh South.

35. Initial survey and data collection for the EIA, including survey of the MCZ, will enable the selection of the landfall location for Norfolk Vanguard. The PEIR and ES will present a single landfall option.

2.2.6 Construction Programme

2.2.6.1 Phasing

36. Norfolk Vanguard may be constructed in the following options and phases:

- A single phase of up to 1800MW;
  - The indicative construction period for a single phase approach is 3 to 5 years.
- Three 600MW phases (HVAC option);
  - A single 600MW phase construction may be 1 to 3 years.
  - The construction periods of each phase may partially overlap, be consecutive, or have a break in between phased construction.
  - The total programme for 1800MW is 3 to 10 years.
- Two 900MW phases (HVDC option)
  - A single 900MW phase construction may be 1 to 3 years.
  - The construction periods of each phase may partially overlap, be consecutive, or have a break in between phased construction.
  - The total programme for 1800MW is 3 to 10 years.

2.2.6.2 Foundation installation duration

37. It is expected that installation of all foundations would take up to a total of 12 months of activity over the whole construction period. As discussed in Section 2.2.4, there may be up to four piling vessels operating concurrently.

38. The worst case scenario for pile driving duration is based on the quadropod option due to this having the greatest number of piles. The piling duration is estimated to be 6 hours per foundation for a 7MW turbine and 12 hours for a 15 to 20MW turbine, allowing contingency for issues such as refusal. The duration of active piling is estimated to be 3 hours per foundation for a 7MW turbine and 6 hours for a 15 to 20MW turbine. The longest overall duration is associated with the maximum number of turbines (i.e. 257 x 7MW)

2.2.6.3 Offshore cable laying

39. Cable laying may take up to a total of 12 months of activity over the whole construction period, with up to two cable laying vessels used simultaneously.

2.2.6.4 Landfall

40. It is expected that landfall HDD works would take up to 30 weeks for HVAC or 10 weeks for HVDC. Cable pull-through will be undertaken subsequent to the duct installation.

2.2.7 Operation and Maintenance (O&M) Strategy

41. Once commissioned, the wind farm would operate for up to 25 years. All offshore infrastructure including wind turbines, foundations, cables and offshore substations would be monitored and maintained during this period in order to maximise efficiency.

42. An estimate of the amount of potential maintenance work required, including vessel numbers and movements, will be provided in the PEIR/ES and included in the impact assessment. This will be based on anticipated planned maintenance as well as an estimated number of unplanned maintenance activities based on experience from other offshore wind farms. Maintenance work may be required to all elements of the offshore project described in Sections 2.2.1 to 26.

43. As discussed in Section 2.2.1, parameters of the floating foundation options are currently being reviewed by the VWPL engineering team and will be available for the EIA. The following operational parameters will be considered in order to assess the impact of floating foundations on marine mammals during operation:

- Mooring line options;
  - Tension;
  - Catenary (with slack to allow the turbine to rise and fall with the tide);
- Mooring line material and diameter.

2.2.8 Decommissioning

44. Decommissioning would most likely involve the accessible installed components comprising: all of the wind turbine components; part of the foundations (those above sea bed level); and the sections of the inter-array cables close to the offshore structures, as well as sections of the export cables. The process for removal of foundations is generally the reverse of the installation process. Possible impacts to marine mammals associated with the decommissioning stage(s) will be further considered as part of the EIA.

45. It is anticipated that a full EIA will be carried out ahead of any decommissioning works to be undertaken.

2.2.9 Summary

Table 2.3 Summary of Indicative Worst Case Parameters for Marine Mammals

<table>
<tr><th rowspan="2">Impact</th><th rowspan="2">Parameter</th><th colspan="2">Maximum worst case</th></tr>
<tr><th>HVAC</th><th>HVDC</th></tr>
<tr><td colspan="4">Construction</td></tr>
<tr><td rowspan="7">Underwater noise from pile driving
(alternative foundation types are also considered but do not represent the worst case scenario for underwater noise)</td><td>Number of wind turbines</td><td colspan="2">257 (7MW devices)
120 (15MW devices)
90 (20MW devices which are the same physical size as 15MW turbines and therefore not the worst case)

The maximum number of turbines will represent the temporal worst case scenario.</td></tr>
<tr><td>Number of offshore platforms</td><td>3 x electrical
2 x met masts
1 x accommodation

The HVAC option represents the worst case scenario due to the increased number of substation platforms</td><td>2 x electrical
2 x met masts
1 x accommodation</td></tr>
<tr><td>Proportion of foundations that are piled</td><td colspan="2">100%</td></tr>
<tr><td>Number of piles per foundation</td><td colspan="2">1 (monopile)
3 (tripod with pin-piles of the same diameter as the quadropod and therefore this will not be the worst case scenario)
4 (quadropod with pin-piles)

The largest pile (15-20MW monopile) will represent the worst case spatial impact. However the 7MW quadropod will represent the worst case temporal impact due to having the greatest number of piles.</td></tr>
<tr><td>Number of piled foundations for 1800MW
- Wind turbines</td><td colspan="2">257 x 1 (7MW monopile) = 257
257 x 4 (7MW quadropod) = 1028
120 x 1 (15MW monopile) = 120
120 x 4 (15MW quadropod) = 480</td></tr>
<tr><td>Number of piled foundations Offshore Platforms</td><td>6 platforms x 1 pile (monopile) = 6
6 platforms x 4 piles (quadropod) = 24</td><td>5 platforms x 1 pile (monopile) = 5
5 platforms x 4 piles (quadropod) = 20</td></tr>
<tr><td>Total number of piled foundations</td><td colspan="2">The worst case scenario total number of piles will be derived from a combination of the worst case scenario for wind turbines and for the offshore platforms based on the above options</td></tr>
</table>

<table>
<tr><th rowspan="2">Impact</th><th rowspan="2">Parameter</th><th colspan="2">Maximum worst case</th></tr>
<tr><th>HVAC</th><th>HVDC</th></tr>
<tr><td></td><td>Hammer energies</td><td colspan="2">Maximum hammer energy:
• 4000kJ (7MW monopile)
• 2700kJ (7MW quadropod)
• 5000kJ (15MW monopile)
• 2700kJ (15MW quadropod)

5000kJ hammer energy represents the worst case scenario for the noise impact at any one time.
The worst case temporal impact will be associated with the 7MW quadropod (2700kJ) foundations due to having the greatest number of piles.</td></tr>
<tr><td></td><td>Pile diameter</td><td colspan="2">8.5m (7MW monopile)
3m (7MW quadropod)
10m (15MW monopile)
5m (15MW quadropod)</td></tr>
<tr><td></td><td>Max. number of phases</td><td>3 x 600MW</td><td>2 x 900MW</td></tr>
<tr><td></td><td>Piling time – single pile</td><td colspan="2">1hr (7MW monopile)
1hr (7MW quadropod)
1hr (15MW monopile)
2hr (15MW quadropod)</td></tr>
<tr><td></td><td>Total active piling time per foundation</td><td colspan="2">3hr (7MW monopile)
3hr (7MW quadropod)
3hr (15MW monopile)
6hr (15MW quadropod)</td></tr>
<tr><td></td><td>Total Piling time – per foundation (providing allowance for issues such as low blow rate, refusal)</td><td colspan="2">6hr (7MW monopile)
6hr (7MW quadropod)
6hr (15MW monopile)
12hr (15MW quadropod)</td></tr>
<tr><td></td><td>Foundation installation period within construction period</td><td colspan="2">12 months of activity within construction period</td></tr>
<tr><td></td><td>Number of concurrent piling events</td><td colspan="2">Up to 4 (2 in NV East + 2 in NV West)</td></tr>
</table>

Impact	Parameter	Maximum worst case	
		HVAC	HVDC
	Min. spacing between piling vessels	616m based on the closest turbine spacing	
	Max. spacing between piling vessels	Limits of the Offshore Wind Farm (OWF) site boundaries	
Underwater noise from seabed preparation, rock dumping and cable installation	Cable installation methods	• Surface laid with cable protection; • Ploughing; • Jetting; • Dredging; • Mass flow excavation; and • Trenching.	
	Inter-array cable length	515km	
	Max no. of cable laying vessels on site	2	
	Duration of cable installation	up to 12 months of activity over the construction period	
	Interconnection cable length	TBC	
	Total export cable length per cable (from substation/ convertor station to landfall)	640km	420km
Barrier Effects	Maximum impact ranges associated with underwater noise	The worst case scenario in relation to barrier effects as a result of underwater noise will be the maximum spatial (i.e. largest pile) and temporal (i.e. longest piling duration) scenarios outlined above.	
Vessels • Underwater noise from vessels • Collision risk • Disturbance to	Maximum number of vessels on site at any one time during construction	Maximum = 119 Average = 71 These numbers are based on all activities occurring concurrently which is unlikely but provides a conservative worst case scenario.	

Impact	Parameter	Maximum worst case	
		HVAC	HVDC
haul out sites	Indicative number of movements	TBC	
	Vessel types	TBC. Assumption that all vessels could have thruster systems and/or ducted propellers.	
	Port locations	TBC	
Changes to prey resource	Impacts upon prey species	See Fish and Shellfish Ecology Method Statement	
Changes to water quality	Impacts on water quality	See Marine Water and Sediment Quality Method Statement	
Operation and maintenance			
Vessels • Underwater noise from vessels • Collision risk	Number of wind farm support vessel trips to site	TBC	
Underwater noise from turbines	Number of wind turbines	257 (7MW devices) 120 (15MW devices)	
	Wind turbine size	7-20MW	
Underwater noise from maintenance activities, such as any additional rock dumping and cable re-burial	Parameters for any cable lengths or areas requiring any additional rock dumping or cable re-burial are unknown, but would be less than during construction.		
Entanglement	Floating foundation mooring lines	Diameter and material TBC	
Impacts upon prey species	Impacts upon prey species	See Fish and Shellfish Ecology Method Statement	
Changes to water quality	Impacts on water quality	See Marine Water and Sediment Quality Method Statement	
Decommissioning			
Underwater noise from foundation removal (e.g. cutting)	Assumed to be as per construction (with no pile driving). Explosives will not be used, assumed piles cut off below seabed level and all structures above seabed level removed.		
Barrier Effects	Maximum impact ranges associated with underwater		The worst case scenario in relation to barrier effects as a

Impact	Parameter	Maximum worst case	
		HVAC	HVDC
	noise		result of underwater noise will be the maximum spatial (i.e. largest pile) and temporal (i.e. longest piling duration) scenarios outlined above.
Vessels • Underwater noise from vessels • Collision risk • Disturbance to haul out sites	Assumed to be similar vessel types, numbers and movements to construction phase (or less).		
Changes to prey resource	Impacts upon prey species		See Fish and Shellfish Ecology Method Statement
Changes to water quality	Impacts on water quality		See Marine Water and Sediment Quality Method Statement

2.2.10 Cumulative Impact Scenarios

46. In addition to Norfolk Vanguard, Vattenfall is also developing the Norfolk Boreas offshore wind farm to the north of NV East, with the EIA following approximately a year behind the Norfolk Vanguard EIA.

47. The development of Norfolk Boreas will use the same offshore cable corridor as Norfolk Vanguard with the addition of a spur to the Norfolk Boreas site.

48. The full implications of the Norfolk Vanguard and Norfolk Boreas cumulative impact scenarios, as well as cumulative impacts with respect to other existing and planned projects (including, but not limited to, East Anglia One, East Anglia Three, East Anglia One North and East Anglia Two), will be fully considered as part of the EIA process.

49. The CIA will include any projects with any potential impacts occurring from the end of the project baseline, as detailed in the ES chapter, until the end of the project. Types of plans or projects to be taken into consideration are:

- Other wind farms;
- Aggregate extraction and dredging;
- Licensed disposal sites;
- Navigation and shipping;
- Planned construction sub-sea cables and pipelines;
- Potential port/harbour development; and

- Oil and gas operations.

50. Screening of specific plans and projects will be follow a stepwise process defined below as:

a) Definition of a study area based on receptor ecology and/or footprint of impact (temporal and spatial).
   i. Spatial boundaries will take account both of the relevant spatial scales for individual receptors (foraging distances, migratory routes) and the spatial extent of environmental changes introduced by developments. These spatial boundaries will be analogous to the extent of the reference populations considered in the impact assessment.
   ii. Temporal boundaries will take account of the project life cycle and the receptor life cycles and recovery times.

b) Establish a source-pathway-receptor rationale. Projects will be screened out where no pathway exists, with clear justification will be provided. This screening process will be species specific.

51. These steps will lead to an initial list of potential projects which could have a cumulative impact with Norfolk Vanguard. The next stage of screening considers the plans or projects where sufficient information exists to undertake an assessment.

52. The CIA will consider projects, plans and activities which have sufficient information available in order to undertake the assessment. Insufficient information will preclude a meaningful quantitative assessment, and it is not appropriate to make assumptions about the detail of future projects in such circumstances. The focus of the assessment will therefore be on those projects or activities where sufficient relevant information exists. Whilst other projects may be acknowledged within the assessment, in the case of inadequate information it is up to the regulator to judge how to take these into account. It is likely that plans or projects with sufficient information to include in the CIA include the stages of developed. This second screening process will follow a tiered approach analogous to that outlined by Joint Nature Conservation Committee (JNCC) and Natural England (undated) in the document 'Suggested Tiers for Cumulative Impact Assessment'.

Table 2.4 Suggested tiers for undertaking a staged cumulative impact assessment (JNCC and Natural England)

Tier Description	Consenting or Construction Phase	Data Availability
Tier 1	Built and operational projects should be included within the cumulative assessment where they have not been included within	Pre-construction (and possibly post-construction) survey data from the built project(s) and environmental

Tier Description	Consenting or Construction Phase	Data Availability
	the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of "baseline" conditions e.g. "background" distribution or mortality rate for birds.	characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project).
Tier 2	Tier 1 + projects under construction	As Tier 1 but not including post-construction survey data
Tier 3	Tier 2 + projects that have been consented (but construction has not yet commenced)	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project) and possibly pre-construction
Tier 4	Tier 3 + projects that have an application submitted to the appropriate regulatory body that have not yet been determined	Environmental characterisation survey data from proposed project (including data analysis and interpretation within the ES for the project)
Tier 5	Tier 4 + projects that the regulatory body are expecting an application to be submitted for determination (e.g. projects listed under the Planning Inspectorate programme of projects)	Possibly environmental characterisation survey data (but strong likelihood that this data will not be publicly available at this stage).
Tier 6	Tier 5 + projects that have been identified in relevant strategic plans or programmes (e.g. projects identified in Round 3 wind farm zone appraisal and planning (ZAP) documents)	Historic survey data collected for other purposes/by other projects or industries or at a strategic level.

53. Each plan or project will be assigned a tier level. The CIA will include all projects classed as tier 1, 2, 3 and 4 in the assessment as a realistic scenario. Consideration will be given to a further assessment including tier 5 and projects, where there is more uncertainty. CIA screening will be undertaken in consultation with stakeholders.

54. Following submission of the PEIR, reviews will be undertaken to ensure that any new information is incorporated into the CIA. Once issues, plans or projects have been scoped out and agreed there must be a strong justification for scoping them back in again, and this will be agreed with statutory consultees.

55. Given the fast moving nature of offshore development, it is likely that new projects relevant to the assessment will arise throughout the pre-application period. In order to finalise an assessment, it will be necessary to have a cut-off period after which no

more projects will be included. A reasonable cut-off point would be the date of receipt of comments upon the PEIR.

2.2.11 Transboundary Impact Scenarios

56. The highly mobile nature of marine mammal species means that there are potential transboundary impacts.

57. For harbour porpoise the extent of the reference population (Section 3.4) includes UK, Dutch, German, French, Belgian, Danish and Swedish waters. For harbour seal the extent of the reference population includes UK, Dutch, German, Belgian and French waters. For grey seal the extent of the reference population includes UK, Dutch, German, Belgian, Danish and French waters. As a result the potential transboundary impacts are embedded within the assessment of impacts on the reference populations.

3 BASELINE ENVIRONMENT

58. The Scoping Report (Royal HaskoningDHV, 2016) provides an overview of the baseline environment based on available information. This section outlines the approach to further characterising the baseline environment for the EIA.

59. Site characterisation will be undertaken using existing data for the former East Anglia Zone (Section 3.1) as well as the site specific data for Norfolk Vanguard (Section 3.1) and other available information for the region.

3.1 Project Specific Data Collection

3.1.1 Aerial Survey

60. APEM is collecting high resolution aerial digital still imagery for marine mammals and ornithology. These data are collected over the Norfolk Vanguard Offshore Wind Farm (OWF) sites and a 4km buffer covering an area of 645 km^2. The surveys capture imagery at 2cm Ground Sampling Distance (GSD). Coverage of the site and 4km buffer has varied between approximately 11% and 12%, dependent on the month since September 2015. As discussed in Section 1.2.3.1, monthly surveys of NV West have been undertaken since September 2015 and are ongoing. Monthly surveys of NV East were completed from September 2015 to April 2016. Further survey data was not collected in NV East following agreement with Natural England that the 24 months of data from East Anglia FOUR from March 2012 and February 2014, as well as data collected for the Zone Environmental Appraisal (see Section 3.2.1), could be utilised to characterise the baseline for EIA.

3.1.1.1 Year 1 Norfolk Vanguard survey results

61. Table 3.1 and Table 3.2 show the marine mammals recorded during the aerial surveys of NV East and NV West, respectively. The results show harbour porpoise are the main species recorded in the offshore wind farm sites (which is comparable with the findings of the surveys outlined in Section 3.2.1).

Table 3.1 NV East marine mammal data

Date	Harbour porpoise	Dolphin / porpoise	White-beaked dolphin	Seal species
September 2015	26	11		
October 2015	4	10		
November 2015	14	30		
December 2015		7		1
January 2016	3	11		
February 2016	23	78	2	

Date	Harbour porpoise	Dolphin / porpoise	White-beaked dolphin	Seal species
March 2016	10	41		
April 2016		14		

Table 3.2 NV West marine mammal data

Date	Harbour porpoise	Dolphin / porpoise	Dolphin species	Seal species
September 2015	46	22	11	
October 2015	4	13		
November 2015	21	30		
December 2015		23		
January 2016	5	42		
February 2016	7	33		
March 2016	3	4	1	
April 2016	10	5		
May 2016		3		1
June 2016				
July 2016	1	1		
August 2016	5	16		

3.2 Available Data

3.2.1 Former East Anglia Zone

62. Marine mammal data have been collected during the extensive aerial surveys across the former Zone and the former East Anglia FOUR as well as the site specific surveys for Norfolk Vanguard. The following surveys encompass or overlap with Norfolk Vanguard (further to those listed in Section 1.2.3.1):

- The Crown Estate Enabling Action data (video aerial survey) of the former zone from November 2009 to March 2010, completed by HiDef Aerial Surveying Ltd;
- APEM aerial survey data of the former Zone from April 2010 to April 2011;
- APEM aerial survey data of the former East Anglia FOUR site with 4km buffer between March 2012 and February 2014;

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

3.2.2 Other available information

64. Further to the surveys within the former Zone, a range of information is available and will be incorporated in the EIA, including:

- Revised Phase III data analysis of Joint Cetacean Protocol (JCP) data resources (Paxton *et al.* 2016);
- The identification of discrete and persistent areas of relatively high harbour porpoise density in the wider UK marine area (Heinänen & Skov 2015);
- Small Cetaceans in the European Atlantic and North Sea (SCANS) Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management (Hammond *et al.* 2013) and SCANS III data, if available;
- Atlas of Cetacean distribution in northwest European waters (Reid *et al,* 2008);
- Management Units for cetaceans in UK waters (IAMMWG 2015);
- UK grey and seal usage maps (Jones *et al.* 2016);
- Special Committee on Seals (SCOS) annual reporting of scientific advice on matters related to the management of seal populations (SCOS, 2015 is the latest annual report, however the 2016 report is likely to be available for the PEIR/ES);
- Defra and JNCC Marine Noise Registry;
- Aerial surveys of harbour seals in the Wadden Sea; and
- Trilateral Seal Expert Group (TSEG) Grey seal surveys in the Wadden Sea and Helgoland.

3.3 Density Estimates

65. Site specific density estimates for Norfolk Vanguard will be calculated for harbour porpoise records as well as harbour porpoise, "dolphin/porpoise" and "dolphin species" combined (see Section 3.1.1.1). During the analysis, consideration will also be given to whether there are sufficient data to calculate estimates for NV East and NV West separately.

66. The following information sources will be considered to provide context to the site specific density estimates:

- Harbour porpoise from the JCP data (Paxton *et al*. 2016) and/or SCANS III data (if available); and
- SMRU seals at sea density data (Jones *et al.* 2016).

3.4 Reference Populations

67. The suggested reference populations in the following sections will be used unless any new data sources become available in time for the assessment.

68. The reference populations will be used to assess impacts as part of the EIA process and may also be used within the HRA assessment (see Section 4.3).

3.4.1 Harbour porpoise

69. The reference population used in the assessment for harbour porpoise will be the North Sea MU (IAMMWG, 2015) with an estimated abundance of 227,298 (CV 0.13, 95% CI 176,360 – 292,948).

3.4.2 Seal Species

3.4.2.1 Grey seal

70. In accordance with the approach agreed with Natural England for other offshore wind farms in the former East Anglia Zone, the reference population extent for grey seal will incorporate the South-east England, North-east England and East Coast IAMMWG MUs and the Waddenzee population.

71. The reference population will be based on the most recent estimate of the Dutch Waddenzee population (e.g. TSEG 2016a) and the most recent counts for the South-east England MU, the north-east England MU and the east Coast Scotland MU (e.g. SCOS 2016).

3.4.2.2 Harbour seal

72. In accordance with the approach agreed with Natural England for other offshore wind farms in the former East Anglia Zone, impacts on harbour seal will be assessed in the context of the following two reference population scenarios:

- Combination of the most recent counts for the :
  - South-east England MU (e.g. SCOS 2016); and
  - The Waddenzee region (e.g. TSEG 2015; no population estimate is provided in TSEG, 2016b).

3.5 Designated Sites – HRA Screening

73. HRA Screening will be undertaken on the basis of the connectivity between Norfolk Vanguard and Natura 2000 sites which have harbour porpoise, bottlenose dolphin, grey seal or harbour seal as a designated conservation feature compared with the predicted impact ranges of the proposed development.

74. An initial list of designated sites will be considered during the Screening and the outputs will be discussed with stakeholders through the Evidence Plan Process to determine which sites require further assessment.

75. As Norfolk Vanguard lies within the Southern North Sea pSAC, this site will be screened in and information to support HRA for this site will be provided with the DCO application (see Section 4.3).

4 IMPACT ASSESSMENT METHODOLOGY

4.1 Defining Impact Significance

76. A matrix approach will be used to assess impacts following best practice, EIA guidance and the approach previously agreed with stakeholders for other recent offshore wind farms (e.g. East Anglia THREE). Receptor sensitivity for an individual from each marine mammal species will be defined within the ES, following definition's set out in Table 4.1. The potential magnitude of effect will be described for permanent and temporary outcomes, as detailed in Table 4.3. The significance of impacts will be assessed using the matrix presented in Table 4.4.

4.1.1 Sensitivity

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

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

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

Table 4.1 Definitions of sensitivity levels for marine mammals

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

4.1.2 Value

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

80. In the case of marine mammals, a large number of species fall within legislative policy; all cetaceans in UK waters are European Protected Species (EPS) and, therefore, are internationally important. Harbour porpoise, bottlenose dolphin, grey seal and harbour seals are also afforded international protection through the designation of Natura 2000 sites, which have seals as a primary reason for site selection. Table 4.2 provides definitions for the value afforded to a receptor based on its legislative importance.

81. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement. It is important not to inflate impact significance simply because a feature is 'valued'.

Table 4.2 Definitions of the value levels for marine mammals

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

4.1.3 Magnitude

82. The thresholds for each category defining the potential magnitude of effect that can occur from a particular impact have been determined using expert judgement, current scientific understanding of marine mammal population biology, and JNCC (2008) draft guidance on disturbance to EPS species. The JNCC (2008) EPS draft guidance suggests definitions for a 'significant group' of individuals or proportion of the population for EPS species. As such this guidance has been considered in defining the thresholds for magnitude of effects.

83. Temporary effects are considered to be of medium magnitude at greater than 5% of the reference population. JNCC (2008) draft guidance considered 4% as the maximum level of mortality that could be sustained by a population of most species

of cetacean. Furthermore, JNCC considers either 2% or 4% a suitable threshold for determining significance of disturbance in species or populations with Favourable Conservation Status (FCS). In assigning 5% to a temporary impact in this assessment, consideration is given to uncertainty of the individual consequences of temporary disturbance.

84. For permanent effects, greater than 1% of the reference population is considered to be high magnitude in this assessment. The assignment of these levels is informed by the JNCC (2008) draft guidance (suggesting between 2% and 4% as being significant) but also reflects the large amount of uncertainty in the potential individual and population level consequences of permanent effects, and what may be considered as the potential rate of increase in a population.

Table 4.3 Definitions of the magnitude levels for marine mammals

Magnitude	Definition
High	Permanent irreversible change to exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >1% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >10% of the reference population are anticipated to be exposed to the effect.
Medium	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that >0.01% or <=1% of the reference population anticipated to be exposed to effect. OR Temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >5% or <=10% of the reference population anticipated to be exposed to effect.
Low	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that >0.001 and <=0.01% of the reference population anticipated to be exposed to effect. OR Intermittent and temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >1% or <=5% of the reference population anticipated to be exposed to effect.
Negligible	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that <=0.001% of the reference population anticipated to be exposed to effect. OR

Magnitude	Definition
	Intermittent and temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that <=1% of the reference population anticipated to be exposed to effect.

4.1.4 Significance

85. Following the identification of receptor sensitivity and the magnitude of the effect, the impact significance will be determined using expert judgement. The matrix (provided in Table 4.4) will be used as a framework to aid determination of the impact assessment. Definitions of impact significance are provided in Table 4.5

86. The JNCC (2008) draft guidance also considers that species of 'unknown' or 'unfavourable' conservation status should be assigned lower thresholds for significance. In the UK the FCS of harbour porpoise, white-beaked dolphin and grey seal is currently favourable, in the case of harbour seal, the overall assessment was inadequate (JNCC, 2007).

Table 4.4 Impact Significance Matrix

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

Table 4.5 Impact Significance Definitions

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

87. For the purposes of this EIA and specifically the marine mammal assessment, it is suggested that 'major' and 'moderate' impacts are deemed to be significant. However, whilst 'minor' impacts would not be deemed significant in their own right, they may contribute to significant impacts cumulatively or through inter-relationships.

4.2 Potential Impacts

4.2.1 Potential Impacts during Construction

4.2.1.1 Impact: Underwater noise

88. Underwater noise has the potential to cause impacts upon marine mammals ranging from behavioural disturbance to injury and death. The noise generated by piling activities has the potential to disturb marine mammals at a considerable distance from the activity (i.e. tens of kilometres from the source) (Thomsen *et al*., 2006; Nedwell *et al.,* 2007; Brandt *et al.,* 2011) and for the duration of piling activities (although intermittently due to breaks in between piles). In very close proximity to piling activities, injuries and in extreme cases, fatalities can occur (Nedwell *et al.,* 2007).

89. Other sources of noise and vibration associated with offshore wind farm construction include vessel noise, seabed preparation, rock dumping and cable installation. However, of these potential sources, piling is of greatest concern and subject to a great deal of investigation within the industry.

90. The potential impact will depend on a number of factors which include:

- The source levels of noise, subject to factors such as:
  - Foundation type

    - Foundation size; and
    - Installation method.
- The spatial footprint of the impact as a feature of noise propagation conditions which will depend on:
    - Sediment/sea floor composition;
    - Water depth; and
    - The sensitivity of marine mammal species present in the area.

4.2.1.1.1 Approach to assessment

91. Subacoustech has been commissioned to undertaken underwater noise modelling. Appendix 1 provides an overview of the proposed approach to the modelling. The hearing thresholds and species to be assessed (outlined in Appendix 1) will be discussed and agreed with stakeholders through the Evidence Plan Process.

92. The pile driving noise modelling will provide the range and area of impacts of lethal and physical injury (including permanent auditory injury) for each species group. The areas will be used to calculate the potential number of individuals, based on the density estimates (see Section 3.3).

93. The impact of other noise sources will be assessed using current scientific knowledge. For vessels, a determination of the likely vessels used during the construction period taken will be used and the known noise emissions of those vessels used to determine the impact of vessel noise to marine mammal receptors. Consideration will be given to existing vessel activity based on site specific data collected during winter and summer shipping surveys and detailed within the Navigational Risk Assessment.

94. Other identified noise sources, such as seabed preparation, rock dumping and cable installations will also be considered using current scientific knowledge.

95. The number of individuals of each species that could be impacted will be considered as a proportion of appropriate the reference population (see Section 3.4).

96. Magnitudes and sensitivities will be based on the best available evidence as discussed within the Marine Mammals Expert Topic Group and subject to a cut-off period after which revisions to the assessment will not be possible.

97. Assessments will be made on the basis of embedded mitigation and proposed mitigation will be discussed and agreed with the topic group.

4.2.1.2 Impact: Barrier effect

98. The impacts of underwater noise, described above could result in a barrier effect for cetaceans transiting north/south in the North Sea or seals moving between feeding grounds and haul out sites.

4.2.1.2.1 Approach to assessment

99. The assessment of barrier effects will take account of the range of potential noise impacts, in particular the predicted extent towards the coastline. The maximum duration of underwater noise impacts and the potential population consequences of barrier impacts over this period will also be considered. An expert judgement will be made regarding the potential impact.

4.2.1.3 Impact: Changes to prey resource

100. Construction activities have the potential to injure or to displace fish species that are sensitive to noise impacts and to increased sediment concentrations and sediment re-deposition. This has potential to affect the food resource of marine mammals.

4.2.1.3.1 Approach to assessment

101. The Fish and Shellfish Ecology Method Statement outlines the proposed approach to the assessment of impacts associated with Norfolk Vanguard. Known prey species for each marine mammal receptor will be assessed based on the resultant significance ratings determined by the Fish and Shellfish Ecology impact assessment. The assessment will consider the known dependence of each marine mammal species to those prey species and the potential impact on energy demands should prey species be displaced. An expert judgement will be made regarding the potential impact.

4.2.1.4 Impact: Vessel interaction

102. Despite the potential for marine mammals to detect and avoid vessels, ship strikes are known to occur in cetaceans and cause injury and death (Wilson *et al*. 2007). Distraction whilst undertaking other activities such as foraging and social interactions are possible reasons why collisions occur (Wilson *et al*. 2007).

4.2.1.4.1 Approach to assessment

103. As for underwater noise impacts associated with vessels, the impact of vessel interaction will be assessed based on the likely vessels used during the construction period. This will be considered in the context of the existing vessel activity based on site specific data collected during winter and summer shipping surveys and detailed

within the Navigational Risk Assessment. An expert judgement will be made using current scientific knowledge.

4.2.1.5 Impact: Disturbance at seal haul out sites

104. Increased activity near seal haul out sites as a result of transiting vessels could have the potential to disturb seals.

4.2.1.5.1 Approach to assessment

105. The likelihood of increased vessels near to the locations of nearby seal haul-out sites will be used to determine the level of potential disruption and behavioural impact caused to the seals, alongside any potential for human and road traffic disturbance. An expert judgement will be made using current scientific knowledge.

4.2.1.6 Impact: Changes to water quality

106. Accidental release of contaminants, increased suspended sediment, or mobilisation of sediment contaminants if contained in those sediments could have potential to impact on marine mammals. The risk of accidental release of contaminants (e.g. through spillage) will be mitigated through appropriate contingency planning and remediation measures for the control of pollution.

107. Sediment sampling at Norfolk Vanguard was undertaken in 2016 and analysis of contaminants is currently underway (see the Marine Sediment and Water Quality Method Statement).

4.2.1.6.1 Approach to assessment

108. An expert judgement will be made using the findings of the Marine Water and Sediment Quality impact assessment. The Marine Water and Sediment Quality Method Statement outlines the proposed approach to the assessment of impacts associated with Norfolk Vanguard (including the release of contaminants, increased suspended sediments, the mobilisation of contaminated sediments and any increase in turbidity).

4.2.2 Potential Impacts during O&M

4.2.2.1 Impact: Underwater noise

109. Noise levels generated by operational wind turbines are much lower than those generated during construction activities. Operational wind turbine noise mainly originates from the gearbox and the generator and has tonal characteristics (Madsen *et al.* 2006; Tougaard *et al.* 2009b). However, recordings of underwater noise are only available from a small number of operational wind farm sites. The main

contribution to the underwater noise emitted from the wind turbines is expected to be from acoustic transfer of the vibrations of the substructure into the water rather than from transmission of in-air noise from the wind turbines into the water column (Lidell, 2003).

110. Noise generated by the operational turbines can be conducted through the tower and foundations into the water. Additional noise sources may include engine noise of maintenance and supply vessels, and any additional rock dumping or cable re-burial. This operational underwater noise has the potential to cause disturbance to marine mammals.

111. Other underwater noise sources associated with construction, such as vessel noise, will be assessed using the same methods as determined in Section 4.2.1.1.1.

4.2.2.1.1 Approach to assessment

112. Available information of the noise emitted by operational offshore wind farms will be considered to determine the potential noise emitted by the turbines. The number of individuals of each species that could be impacted will be estimated as a proportion of appropriate the reference population.

4.2.2.2 Impact: Changes to prey resource

113. Potential impacts on marine mammal prey species will be assessed in the Fish and Shellfish Ecology Chapter using the appropriate realistic worst case scenario for these receptors. The Fish and Shellfish Ecology Method Statement outlines the proposed approach to the assessment of impacts associated with the O&M of Norfolk Vanguard.

4.2.2.2.1 Approach to assessment

114. The approach for the assessment of changes to prey resources during O&M will be the same as for construction (Section 4.2.1.3.1).

4.2.2.3 Impact: Vessel interactions

115. As with construction vessels, maintenance vessels present potential interactions with marine mammals, however there will be significantly less vessels and movements associated with O&M.

4.2.2.3.1 Approach to assessment

116. The approach for the assessment of vessel interaction during O&M will be the same as for construction (Section 4.2.1.4.1).

4.2.2.4 Impact: Changes to water quality

117. If floating foundations with catenary mooring are used, movement of the mooring lines on the seabed has the potential to cause suspension of sediments.

118. Potential changes in marine physical processes in the area caused by the deployment of the wind farm may also alter suspended sediment concentrations and deposition.

119. In addition, small volumes of sediment could be re-suspended during maintenance activities as a result of the physical disturbance discussed in Section 4.2.2.2.

4.2.2.4.1 Approach to assessment

120. An expert judgement will be made using the findings of the Marine Water and Sediment Quality impact assessment. The Marine Water and Sediment Quality Method Statement outlines the proposed approach to the assessment of impacts associated with Norfolk Vanguard during O&M.

4.2.3 Potential Impacts during Decommissioning

121. The types of effect would be comparable to those identified for the construction phase, namely:

- Underwater noise
- Barrier effects
- Changes to prey resource
- Vessel interactions
- Disturbance at haul out sites
- Changes to water quality

4.2.3.1.1 Approach to assessment

122. The likely underwater noise emitted during decommissioning of offshore wind farms will be determined to assess the potential impacts on marine mammals. The number of individuals of each species that could be impacted will be considered as a proportion of appropriate the reference population.

123. The approach to the other cumulative impacts will be as for construction, outlined in Section 4.2.1.

4.2.4 Potential Cumulative Impacts

124. The potential for projects to act cumulatively on marine mammals will be considered in the context of the likely spatial and temporal extent of impacts. Each potential impact described for the construction and O&M phases of Norfolk Vanguard will be considered in the CIA.

4.2.4.1.1 Approach to assessment

125. The CIA will review the impact assessments for other projects where this is publically available and will make assumptions regarding Norfolk Boreas based on VWPL's plans for this project to determine the magnitude of the cumulative impact along with Norfolk Vanguard. Where quantitative assessments are available, the total number of marine mammals potentially affected will be considered in the context of the reference populations.

126. Each potential impact described for the construction and O&M phases of Norfolk Vanguard will be considered in the CIA.

127. There will be an inherent level of uncertainty associated with assessments of impacts on this basis. It is important that stakeholders understand that significant cumulative impacts may be the result of an overly precautionary worst case (or precaution built on precaution) and that this will be highlighted within documents and discussions.

4.3 Information for HRA

128. The HRA screening (see Section 3.5) will determine the sites for which there are potential effect pathways from Norfolk Vanguard. The HRA will then consider the effects covered by the EIA in terms of designated sites.

129. As discussed in Section 3.5, Norfolk Vanguard lies within the Southern North Sea pSAC. The section below outlines the key information that will be identified within the Information to Support HRA report in relation to the pSAC. The Information to Support HRA will also consider other sites as appropriate, once more information is known about the potential impact ranges of Norfolk Vanguard to allow the HRA screening to be completed.

4.3.1 Southern North Sea pSAC

4.3.1.1 Potential Effects

130. The HRA will consider the draft conservation objectives of the Southern North Sea pSAC (JNCC and Natural England (2016); shown in Table 4.6) subject to any revisions which will be discussed through the marine mammal expert topic group.

131. The approach to the HRA will be discussed through ongoing meetings of the Norfolk Vanguard marine mammal expert topic group, as well as wider industry workshops. Given the ongoing development of the pSAC, it is likely that new information and guidance becomes available during the course of the Norfolk Vanguard EIA. In order to finalise the information to include within the DCO application, it will be necessary to have a cut-off period after any further developments will be considered during

the examination phase. A reasonable cut-off point would be the date of receipt of comments upon the PEIR.

4.3.1.2 Conservation objectives

132. The HRA will consider the draft conservation objectives of the Southern North Sea pSAC (shown in Table 4.6) subject to any revisions which will be discussed through the marine mammal expert topic group.

Table 4.6 Potential effects and results of HRA Screening for the proposed East Anglia THREE project in relation to the draft Conservation Objectives for the Southern North Sea pSAC

Draft Conservation Objective	Potential effect
The species is a viable component of the site	Lethal effects and auditory injury from underwater noise during installation and operation
	Disturbance and displacement as a result of increased underwater noise levels during construction
	Increased collision risk with vessels during installation and operation
There is no significant disturbance of the species	Disturbance and displacement as a result of increased underwater noise levels during construction
The supporting habitats and processes relevant to harbour porpoises and their prey are maintained	Changes in prey availability
	Re-suspension of sediment during installation
	Accidental release of contaminants

4.3.1.3 Abundance / reference population

133. The potential impacts on the pSAC associated with Norfolk Vanguard, as well as cumulative impacts with other projects, will be assessed on the basis of the North Sea MU reference population for harbour porpoise. This is in line with JNCC and Natural England (2016) draft Conservation Objectives and Advice on Activities, which states that the key concern with regards to the pSAC is how the impacts within the site translate into effects on the harbour porpoise population, especially with regard to underwater noise impacts.

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APPENDIX 1 UNDERWATER NOISE MODELLING METHOD

Method Statement relating to underwater noise propagation modelling parameters

Underwater noise propagation modelling is proposed as part of the Environmental Impact Assessment (EIA) for Norfolk Vanguard. As part of this, a decision must be made as to certain modelling parameters in the Evidence Plan Process. This Method Statement by Subacoustech, examines the methodology used in the East Anglia Three Offshore Wind Farm (OWF) EIA as the most recent EIA to go through examination and updates it based on best available current research and guidelines.

Modelling

The underwater noise modelling will utilise a combined parabolic equation (as per RAM/RAMSGeo) and ray-tracing (for high frequency elements) solver within the dBSea package. This incorporates bathymetry and seabed and sediment data to ensure realism to the environment. During modelling, the results will be precautionary, using the worst case for:

- Hammer energies
- Ramp-up profiles
- Cumulative noise exposure
- Position of the receptor in the water column

The impact criteria to be applied are also designed to be conservative.

Thresholds and criteria

Underwater noise impacts on marine life are under investigation around the world and new research is published frequently. Two key and current papers concerning underwater noise impacts have been published: NMFS (2016)[4] and the American National Standards Institute (ANSI)-approved Popper *et al.* (2014)[5], for marine mammals and fish, respectively. These update the recommended criteria for use in impact assessments.

[4] National Marine Fisheries Service. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

[5] Popper A N, Hawkins A D, Fay R R, Mann D A, Bartol S, Carlson T J, Coombs S, Ellison W T, Gentry R L, Halvorsen M B, Løkkeborg S, Rogers P H, Southall B L, Zeddies D G, Tavolga W N., ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles, Springer Briefs in Oceanography, DOI 10.1007/978-3-319-06659-2

Marine Mammals

Since it was published in 2007, Southall *et al*[6] has been the source of the most widely used criteria to assess the effects of noise on marine mammals. The Norfolk Vanguard Scoping Opinion advises that NMFS (2016) impact criteria are reviewed. NMFS (2016) was co-authored by many of the same authors from Southall *et al.* and effectively updates it. Most criteria become more restrictive.

Table A1 shows the criteria used in the underwater noise impact assessment for East Anglia THREE and the most up to date criteria provided by NMFS (2016). The criteria are divided into species 'hearing groups' which represent the sound frequencies over which the group of species are sensitive. The thresholds to be used in the Norfolk Vanguard EIA will be discussed and agreed with stakeholders through the Evidence Plan Process.

Table A1 Criteria for assessment of injury to marine mammals

PTS (Permanent Threshold Shift)	East Anglia Three		NMFS (2016)	
	SPL_{peak} Unweighted (dB re 1 μPa)	SEL_{cum} Weighted (dB re 1 $\mu Pa^2 s$)	SPL_{peak} Unweighted (dB re 1 μPa)	SEL_{cum} Weighted (dB re 1 $\mu Pa^2 s$)
High Frequency (HF) Cetaceans (e.g. Harbour porpoise)	200	179 (single strike)	202	155
Mid Frequency (MF) Cetaceans (e.g. Bottlenose dolphin)	230	198	230	185
Low Frequency (LF) Cetaceans (e.g. Baleen whales)	230	198	219	183
Phocid Pinnipeds (e.g. harbour seal)	218	186	218	185

East Anglia THREE used an assumption that a fleeing response or avoidance of an area occurred concurrently with the noise exposure believed to cause a temporary reduction in hearing sensitivity (Temporary Threshold Shift or "TTS"). Table A2 represents the criteria for this effect, and therefore the concurrent fleeing response.

Table A2 Criteria for assessment of TTS to marine mammals

TTS (Temporary Threshold Shift)	East Anglia THREE		NMFS (2016)	
	SPL_{peak} Unweighted (dB re 1 μPa)	SEL_{cum} Weighted (dB re 1 $\mu Pa^2 s$)	SPL_{peak} Unweighted (dB re 1 μPa)	SEL_{cum} Weighted (dB re 1 $\mu Pa^2 s$)
High Frequency (HF) Cetaceans (e.g. Harbour porpoise)	194	164	196	140
Mid Frequency (MF) Cetaceans (e.g. Bottlenose dolphin)	224	183	224	170
Low Frequency (LF) Cetaceans (e.g. Baleen whales)	224	183	213	168
Phocid Pinnipeds	212	171	212	170

[6] Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr., C. R., Kastak, David, Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L. (2007) Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations, Aquatic Mammals, 33 (4), pp. 411-509

(e.g. harbour seal)				

While, strictly speaking, the criteria are designed for TTS rather than fleeing, this follows the methodology agreed for use in East Anglia THREE's criteria, as there is little broadly accepted evidence currently available for setting behavioural avoidance criteria. However, the following alternative criteria applied for East Anglia THREE could be used, which are identified in the table below, derived from Southall *et al.*, 2007.

Table A3 Criteria for assessment of potential avoidance of an area by marine mammals

Potential avoidance of area	East Anglia THREE	
	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Weighted (dB re 1 µPa^{2}s)
High Frequency (HF) Cetaceans (e.g. Harbour porpoise)	168	145
Mid Frequency (MF) Cetaceans (e.g. Bottlenose dolphin)	None	160-170
Low Frequency (LF) Cetaceans (e.g. Baleen whales)	None	142-152
Phocid Pinnipeds (e.g. harbour seal)	As TTS	As TTS

Fish

The vast variety and variation in fish species leads to a greater challenge in production of a generic noise criterion, or range of criteria, for the assessment of noise impacts. Whereas previously broad criteria were applied based on limited studies, the publication of Popper *et al.* (2014) provides an authoritative summary of the latest sound exposure guidelines. The following table provides a summary of the most conservative of these, in respect of offshore pile driving, alongside the criteria recommended for East Anglia THREE.

Table 7 Criteria for assessment of effects on fish

Effect on fish	East Anglia Three		Popper *et al.* (2014)	
	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Unweighted (dB re 1 µPa^{2}s)	SPL_{peak} Unweighted (dB re 1 µPa)	SEL_{cum} Unweighted (dB re 1 µPa^{2}s)
Fish injury	206	211	207	203
TTS	None	None	None	186
Startle response / C-turn reaction	200	None	Qualitative	Qualitative
General behavioural response	168 – 173	None	Qualitative	Qualitative

The Popper *et al.* guidelines do not recommend quantitative criteria for behavioural effects on fish as the best research available is limited to very specific studies on species under artificial conditions. Therefore it is recommended that behavioural effects for fish are considered qualitatively only.

It should be noted that two follow-ups to the Popper *et al.* (2014) report (Hawkins *et al.* 2015[7], Hawkins and Popper 2016[8]) elaborate further on the challenge of setting criteria for the large variety

[7] Hawkins, A. D., Pembroke, A., and Popper, A. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries, 25: 39–64

of sensitivities of the many species of fish and invertebrates. The reports detail the data gaps, especially in relation to many species sensitive to the particle motion rather than pressure component of sound in the water and to the potential for impacts from seabed vibration. Although clearly identifying that many species will not be sensitive to the sound pressure for which the criteria are based, there are neither recognised criteria or thresholds in terms of particle motion currently available, nor appropriate data to apply the criteria to.

The papers make a strong recommendation to undertake research to fill these data gaps. Until such research exists, however, it is recommended to continue to use the existing criteria as defined in Popper *et al.* 2014 as best practice.

Piling locations

Concurrent piling at two locations within NV East and two in NV West will be modelled for locations at the furthest extent of the boundaries, in order to provide the maximum combined sound propagation. Consideration will also be given to seabed bathymetry when selecting the worst case scenario concurrent piling locations.

The underwater noise modelling will also assess the worst case scenario for noise propagation at a single piling location within NV East and NV West which may be represented by one of the locations identified for concurrent piling or may be a new location, subject to the bathymetry data.

In addition, the maximum noise impact contour for harbour porpoise will be modelled at one location with NV East and NV West which provides the maximum overlap with the Southern North Sea proposed Special Area of Conservation. This may be represented by one of the locations identified above or may be a new location.

A geophysical survey at Norfolk Vanguard was undertaken in 2016 and the bathymetry data from this will be assessed to identify the worst case scenario location, when available.

[8] Hawkins, A. D., and Popper, A. N. 2016. A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsw205

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Norfolk Vanguard Offshore Wind Farm

Habitats Regulations Assessment

Marine Mammal Method Statement

Document Reference: PB4476-003-043

Author: Royal HaskoningDHV
Date: May 2017
Client: Vattenfall Wind Power Ltd

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
15/06/17	00D	1st draft for internal review	GK	JL	AD
19/06/17	01D	1st draft for Vattenfall review	GK	JL	AD
21/06/17	02D	Incorporating Vattenfall comments For circulation to the EPP ETG	GK		AD

This method statement has been prepared by Royal HaskoningDHV on behalf of Vattenfall Wind Power Limited (VWPL) to inform the Evidence Plan Process. All content and material within this document is draft for consultation purposes.

Royal HaskoningDHV Enhancing Society Together

VATTENFALL

Table of Contents

1 INTRODUCTION

1. The purpose of this method statement is to outline the proposed approach for the shadow Habitats Regulations Assessment (HRA) for Norfolk Vanguard in relation to marine mammals, with the aim of seeking agreement through the Evidence Plan Process (EPP).

2. The approach outlined in this method statement takes account of previous correspondence with stakeholders, including:

- The Scoping Opinion (the Planning Inspectorate, 2016);
- Meeting with Natural England and the MMO to discuss aerial survey scope 21st March 2016 (see final minutes);
- Evidence Plan Process marine mammal topic group meeting 15th February 2017 (see final minutes); and
- Natural England's Current Advice on Assessment of Impacts on the Southern North Sea Harbour Porpoise cSAC 13th June 2017

3. The primary aim of this method statement is to seek agreement on the approach to HRA for Norfolk Vanguard in relation to marine mammals. However, it is acknowledged that new information and guidance may become available during the course of the Norfolk Vanguard EIA, through ongoing meetings of the Norfolk Vanguard marine mammal expert topic group, as well as wider industry workshops. This will be incorporated in to the HRA process where appropriate. It will be necessary to have a cut-off date in the HRA process to allow adequate time to prepare submissions for the Development Consent Order (DCO) application submission. After this cut-off date, any further developments will be considered during the examination phase. It was agreed with the marine mammal topic group at the Evidence Plan meeting on 15th February 2017 that a reasonable cut-off point is the date of receipt of comments upon the Preliminary Environmental Information Report (PEIR).

2 PROJECT UPDATE

2.1 Site selection

4. Since the last marine mammal topic group meeting in February 2017, site selection work has been ongoing and the Happisburgh South landfall search area has been selected, removing the alternative options further north. The offshore cable corridor has also been refined to align with this landfall location (Figure 2.1).

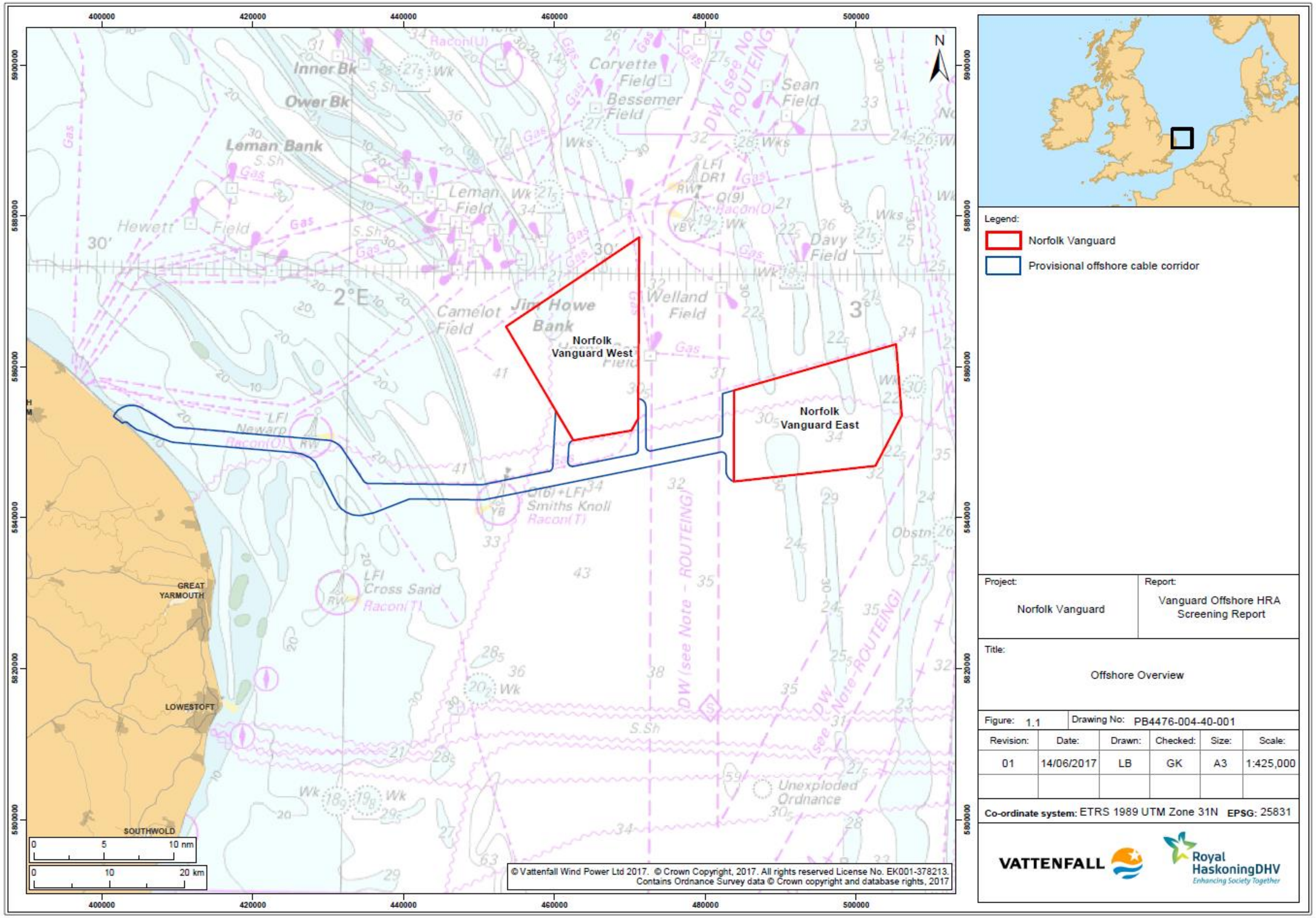

Figure 2.1 Norfolk Vanguard offshore project areas

2.2 Norfolk Vanguard Programme

5. The programme remains unchanged from previous EPP correspondence and is summarised below.

2.2.1 EIA Programme

6. The EIA programme:

- Scoping Request submission - 03/10/16 (complete)
- Preliminary Environmental Information submission - Oct/Nov 2017
- Environmental Statement and DCO submission - Q2 2018

2.2.2 Evidence Plan Process programme

7. The Evidence Plan Terms of Reference provides an overview of the Evidence Plan Process (EPP) and expected logistics, below is a summary of anticipated meetings:

- Steering Group meeting (*complete*) - 21/03/16
- Steering Group meeting (*complete*) - 20/09/16
- Post-scoping Expert Topic Group meetings (*complete*) - Jan/Feb 2017
- Update Expert Topic Group and Steering Group meetings as required - July 2017
- PEIR Expert Topic Group and Steering Group meetings - Sept 2017
  - To discuss the findings of the PEI before submission
- Pre-submission Expert Topic Group and Steering Group meetings - Q1/Q2 2018
  - To discuss updates to the PEIR prior to submission of the ES

2.2.3 Survey Programme

8. Draft information to support HRA will be submitted with the PEIR and will be based on 1.5 years of site specific survey data for Norfolk Vanguard West (NV West). The final submission will be based on 2 years of site specific survey data.

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

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

3 APPROACH TO HRA

3.1 HRA Screening

10. An Offshore HRA Screening Report is provided separately which outlines the proposed sites to be discounted or considered further within the HRA and the justification for this. The HRA screening process is the first part of considering Article 6(3), identifying and screening in to the HRA process those sites on which the proposed project is likely to have a significant effect.

11. In relation to marine mammals, the following sites have been screened in:

- Southern North Sea candidate Special Area of Conservation (cSAC) (harbour porpoise)
- The Wash and North Norfolk Coast Special Area of Conservation (SAC) (harbour seal)
- The Humber Estuary SAC (grey seal)

12. This document provides the proposed approach to the assessment of effects on these designated sites. The assessment will also draw on information that will be collated through the Environmental Impact Assessment (EIA).

3.1.1 Southern North Sea cSAC

13. Norfolk Vanguard lies within the Southern North Sea cSAC (Figure 3.1). The HRA will consider the draft conservation objectives of the Southern North Sea cSAC (shown in Table 3.1) subject to any revisions which will be discussed through the marine mammal expert topic group. Table 3.1 outlines the potential effects that will be considered further in the shadow HRA.

Table 3.1 Potential effects and results of HRA Screening for Norfolk Vanguard in relation to the draft Conservation Objectives for the Southern North Sea cSAC (source JNCC and Natural England, 2016)

Draft Conservation Objective	Potential effect
The species is a viable component of the site	Lethal effects and auditory injury from underwater noise associated with piling will be considered further). Such impacts from the clearance of Unexploded Ordnance (UXO) will be mitigated (see Section 3.3.1) and therefore there is no potential for LSE.
	Disturbance and displacement as a result of increased underwater noise levels (e.g. from UXO clearance, piling, other construction activities, vessels, operational and maintenance (O&M) noise, and noise associated with decommissioning phase works) have the potential to have an effect on the site and will be considered further.

Draft Conservation Objective	Potential effect
	Increased collision risk with vessels during installation, operation and decommissioning has the potential to have an effect on the site and will be considered further.
There is no significant disturbance of the species	Significant disturbance and displacement as a result of increased underwater noise levels (e.g. from UXO clearance, piling, other construction activities, vessels, O&M noise, and noise associated with decommissioning phase works) have the potential to have an effect on the site and will be considered further.
The supporting habitats and processes relevant to harbour porpoises and their prey are maintained	Changes in prey availability have potential to effect the site and will be considered further.

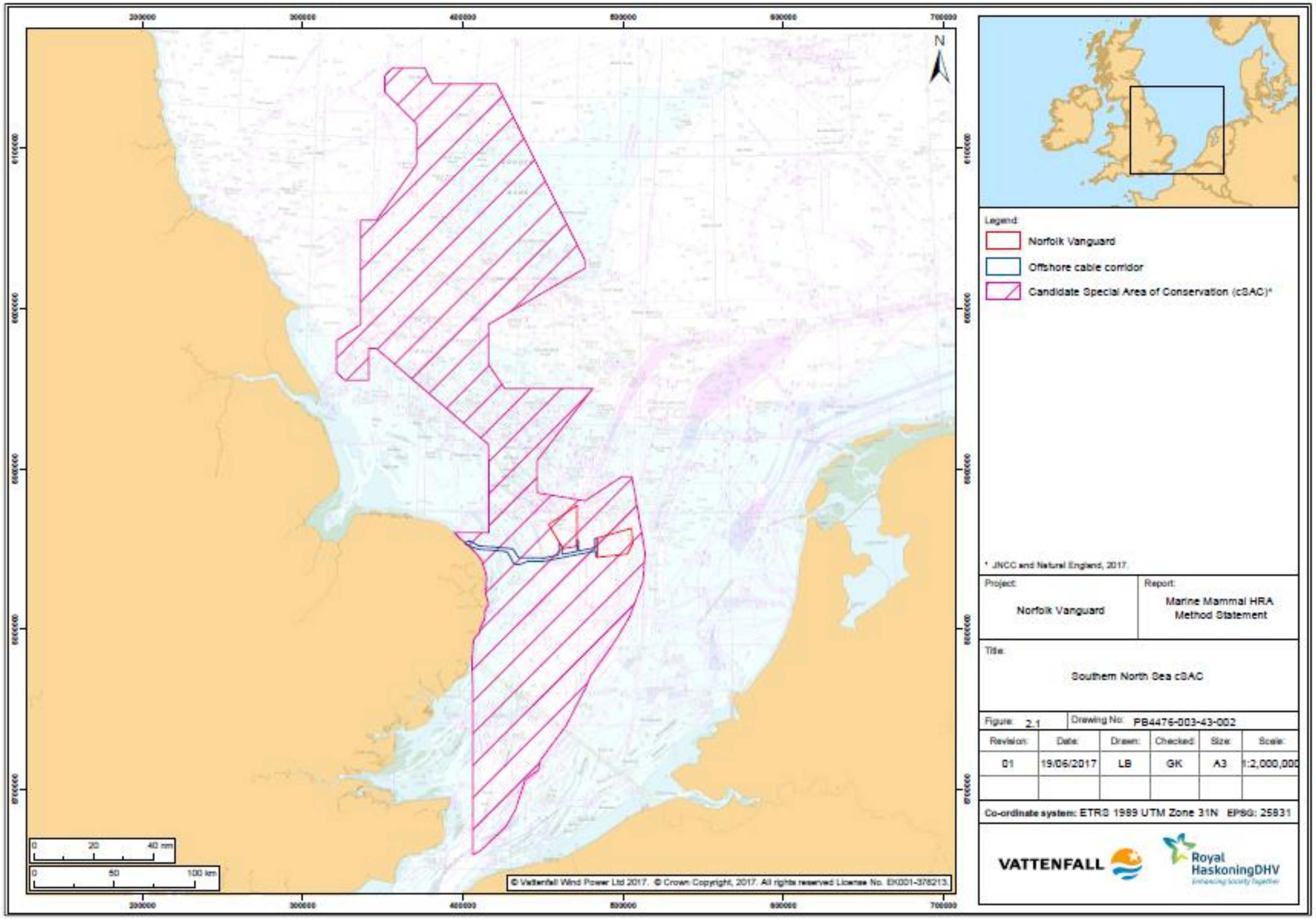

Figure 3.1 Southern North Sea cSAC

3.1.2 The Wash and North Norfolk Coast SAC

14. The HRA screening identified potential for vessels associated with Norfolk Vanguard to interact with harbour seals from the Wash and North Norfolk Coast SAC depending on the location of the port. A port on the east coast of England is likely to be used during construction and therefore vessels travelling between the offshore project area and the construction port may transit passed the Wash and North Norfolk Coast SAC.

15. No other potential effects on the Wash and North Norfolk Coast SAC were identified during the HRA screening.

16. The potential effects in relation to the conservation objectives for the Wash and North Norfolk Coast SAC are outlined in Table 3.2.

Table 3.2 Potential effects and results of HRA Screening for Norfolk Vanguard in relation to the Conservation Objectives for the Wash and North Norfolk Coast SAC

Draft Conservation Objective	Potential effect
The extent and distribution of qualifying natural habitats and habitats of qualifying species	No potential Likely Significant Effect (LSE)
The structure and function (including typical species) of qualifying natural habitats	No potential LSE
The structure and function of the habitats of qualifying species	No potential LSE
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely	No potential LSE
The populations of qualifying species	Increased collision risk with vessels during installation and operation – Potential LSE to be considered further
The distribution of qualifying species within the site	No potential LSE

3.1.3 The Humber Estuary

17. The HRA screening identified potential for vessels associated with Norfolk Vanguard to interact with grey seals from the Humber Estuary SAC.

18. Whilst no decision regarding the construction or O&M port has been taken, it is possible that vessels travelling between the offshore project area and the port may transit past the Humber Estuary SAC.

19. No other potential effects on the Humber Estuary SAC were identified during the HRA screening.

20. The potential effects in relation to the conservation objectives for the Humber Estuary SAC are outlined in Table 3.3.

Table 3.3 Potential effects and results of HRA Screening for Norfolk Vanguard in relation to the Conservation Objectives for the Humber Estuary SAC

Draft Conservation Objective	Potential effect
The extent and distribution of qualifying natural habitats and habitats of qualifying species	No potential Likely Significant Effect (LSE)
The structure and function (including typical species) of qualifying natural habitats	No potential LSE
The structure and function of the habitats of qualifying species	No potential LSE
The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely	No potential LSE
The populations of qualifying species	Increased collision risk with vessels associated with Norfolk Vanguard may cause a potential LSE which will be considered further
The distribution of qualifying species within the site	No potential LSE

3.2 Characterising the Baseline Environment

21. The baseline environment will be characterised in the Preliminary Environmental Information Report (PEIR) and Environmental Statement (ES) which will be used to inform the HRA. This will follow the approach outlined in the Norfolk Vanguard Marine Mammal Method Statement, February 2017, and agreed with the marine mammal topic group at the Evidence Plan meeting on 15th February 2017.

3.2.1 Southern North Sea cSAC harbour porpoise reference population

22. The reference population used in the Environmental Impact Assessment (EIA) for harbour porpoise is the North Sea Management Unit (MU) (IAMMWG, 2015) with an estimated abundance of 227,298 (CV = 0.13, 95% CI = 176,360 – 292,948) based on the Hammond *et al*. (2013) analysis of the SCANS-II data. In addition, for the HRA it was agreed with the marine mammal topic group at the Evidence Plan meeting on 15th February 2017 that this reference population should be considered along with the estimate that the cSAC supports 17.5% MU population (i.e. 39,777 animals).

3.2.2 The Wash and North Norfolk Coast SAC harbour seal reference population

23. The reference population for harbour seal that encompasses the Wash and North Norfolk Coast SAC is the south-east England MU. The harbour seal count based on surveys from 2008 to 2015 for this area was 4,740 (SCOS, 2016). The mean harbour

seal count for the Wash in 2015 was 3,336 (SCOS, 2016). The reference population proposed to be used in the assessment will be 4,740 harbour seal.

3.2.3 The Humber Estuary SAC grey seal reference population

24. The reference population for grey seal that encompasses Humber Estuary SAC is the south-east England MU, although the SAC is located close to the north-east MU (IAMMWG, 2013). The latest grey seal counts from the north-east England MU and south-east England MU in August 2015 were 6,942 and 5,637, respectively (SCOS, 2016). Therefore the reference population to be used in the assessment will be 12,579 grey seal.

3.3 Indicative Worst Case Scenarios

3.3.1 Embedded mitigation

3.3.1.1 Underwater noise

25. Norfolk Vanguard Ltd will commit to the following embedded mitigation in order to reduce potential effects on marine mammal Natura 2000 sites:

- The use of piling soft start for 20 minutes at 10% of the maximum hammer energy followed by a gradual ramp up for at least 40 minutes to the maximum hammer energy as required.
- A mitigation zone will be identified based on instantaneous Permanent Threshold Shift (PTS) impact ranges. Mitigation measures will aim to remove marine mammals from the mitigation zone prior to the start of piling.
- A draft marine mammal mitigation plan (MMMP) will be provided with the DCO application. The final MMMP will be developed in the pre-construction period and will be based upon best available information and methodologies at that time in consultation with the relevant authorities.

3.3.1.2 Vessels

26. Vessels would follow recognised routes from and to the relevant ports. Vessel movements associated with the wind farm will be controlled by marine co-ordination with the aim of minimising vessel traffic over the wider area.

3.3.1.3 Water Quality

27. The risk of accidental release of contaminants (e.g. through spillage) will be mitigated through appropriate contingency planning and remediation measures for the control of pollution and therefore changes to water quality are not considered

further, in accordance with the scoping report (Royal HaskoningDHV, 2016) and scoping opinion (the Planning Inspectorate, 2016).

3.3.2 Unexploded ordinance

28. A detailed Unexploded Ordinance (UXO) survey will be completed prior to construction and some clearance operations may be required where micro-siting is not possible. The quantity of UXO clearance operations is therefore not known at this stage and an estimate will be made to inform the HRA, for example based on the best available information from wind farms within the southern North Sea. Piling

29. A range of foundation options; jacket (tripod or quadropod), gravity base, suction caisson, monopile and tension leg floating platforms (see Plate 3.1) will be included in the project design envelope. Monopiles, jackets and floating foundations would require between one and four piles per foundation (depending on the foundation type).

Plate 3.1 Indicative tension leg floating platforms

30. The total piling duration for the installation of the maximum number of turbines (257) is 771 hours (approximately 32 days) within the overall construction programme, see Section 3.3.5 Indicative Construction Programme.

31. Up to four concurrent piling events (two in NV East and two in NV West) may be undertaken.

32. Table 3.4 outlines the maximum hammer energies and maximum number of piles for monopiles (8.5m and 10m diameter) and pin-piles (3m and 5m diameter) that could

be required to install the wind turbines and substations. The maximum total number of piles for Norfolk Vanguard would be 1076.

33. The maximum hammer energy used during construction of Norfolk Vanguard will be 5,000kJ for the largest monopiles or 2700kJ for pin-piles. The underwater noise modelling considers soft-start hammer energies of 10% of the maximum.

Table 3.4 Maximum piling hammer energies and number of piles for wind turbines and substations (greyed values do not represent the worst case number of piles)

Parameter	7MW pin-pile or floating	15-20MW pin-pile or floating	7MW monopile	15-20MW monopile	Substation on monopile	Substation on pin-pile	Accommodation Platform on pin-pile	Met masts	Lidar
Pile diameter (m)	3	5	8.5	10	10	5	3	3	3
Number of piles per foundation	3-4	3-4	1	1	1	3-4	3-4	3-4	3-4
Maximum hammer energy (kJ)	2700	2700	4000	5000	5000	2700	2700	2700	2700
Starting energy (kJ)	270	270	400	500	500	270	270	270	270
Maximum no. of turbines and substations	257	120-90	257	120-90	6	6	2	2	2
Maximum no. of piles	1028	480	257	120	6	24	8	8	8

3.3.3 Layout

34. The layout of wind turbines will be determined pre-construction based on post consent site investigation works and detailed design works. The minimum spacing will be four times the turbine diameter (616m based on the minimum diameter of 154m) and the maximum spacing will be 15 times the turbine diameter (4.5km based on the maximum diameter of 303m).

35. The maximum capacity that may be located in NV West will be up to 1800MW (i.e. 100% of the turbines) and the maximum capacity in NV East will be up to 1200MW (i.e. 67% of the turbines) with the remaining 600MW in NV West. Consideration will be given to which locations represent the maximum overlap for the summer and winter Southern North Sea cSAC areas.

3.3.4 Phasing

36. Different phasing scenarios will be considered in relation to effects on SACs/cSAC. Norfolk Vanguard may be constructed in the following options and phases:

- A single phase of up to 1800MW;
  - The indicative construction period for the single phase approach is 3 to 5 years.
- Two 900MW phases (HVDC option)
  - A single 900MW phase construction may be 1 to 3 years.
  - The construction periods of each phase may partially overlap, be consecutive, or have a break in between phased construction.
  - The total programme for 1800MW is 3 to 10 years depending on the time between commencement of phases.
- Three 600MW phases (HVAC option);
  - A single 600MW phase construction may be 1 to 3 years.
  - The construction periods of each phase may partially overlap, be consecutive, or have a break in between phased construction.
  - The total programme for 1800MW is 3 to 10 years depending on the time between commencement of phases.

3.3.5 Indicative Construction Programmes

37. The indicative construction programmes for one, two or three phased construction scenarios are shown in Table 3.5, Table 3.6 and Table 3.7 respectively.

Table 3.5 Indicative One Phased Construction Programme

Construction	Months	Start	Finish
Overall programme – 1 x 1800MW phase	**22**	**May 2024**	**March 2026**
Foundation installation	15	May 2024	Jan 2026
Array cable installation	14	July 2024	Jan 2026

Construction	Months	Start	Finish
Topside/ wind turbine installation	15	July 2024	March 2026
Commissioning window	16	Aug 2024	June 2026

Table 3.6 Indicative Two Phased Construction Programme

Construction	Months	Start	Finish
Overall programme – 2 x 900MW phases	**23**	**May-24**	**Mar-26**
Phase 1 Construction			
Programme – 1 x 900MW phase	13	May 2024	May 2025
Foundation installation	9	May 2024	Jan 2025
Array cable installation	8	July 2024	Feb 2025
Topside/ wind turbine installation	9	July 2024	Mar 2025
Commissioning window	11	Aug 2025	June 2026
Phase 2 Construction			
Programme – 1 x 900MW phase	13	May 2025	May 2026
Foundation installation	9	May 2025	Jan 2026
Array cable installation	8	May 2025	Dec 2025
Topside/ wind turbine installation	9	Jul 2025	March 2026
Commissioning window	11	Aug 2026	June 2026

Table 3.7 Indicative Three Phased Construction Programme

Construction	Months	Start	Finish
Overall programme – 3 x 600MW phases	**34**	**May 2024**	**March 2027**
Phase 1 Construction	13	May 2024	June 2025
Programme – 1 x 600MW phase	8	May 2024	March 2025
Foundation installation	6	May 2024	Jan 2025
Array cable installation	5	July 2024	Jan 2025
Topside/ wind turbine installation	6	July 2024	March 2025
Commissioning window	7	Aug 2024	June 2025
Phase 2 Construction	13	May 2025	June 2026
Programme – 1 x 600MW phase	9	May 2025	May 2026
Foundation installation	6	May 2025	Jan 2026
Array cable installation	5	May 2025	Jan 2026
Topside/ wind turbine installation	6	July 2025	March 2026
Commissioning window	7	Aug 2025	June 2026
Phase 3 Construction	13	May 2026	June 2027
Programme – 1 x 600MW phase	8	May 2026	March 2027
Foundation installation	6	May 2026	Jan 2027
Array cable installation	5	July 2026	Jan 2027
Topside/ wind turbine installation	6	July 2026	March 2027
Commissioning window	7	Aug 2026	June 2027

3.3.6 Vessel movements

3.3.6.1 Construction vessels

38. Indicative vessel movements (return trips to a local port) for construction of Norfolk Vanguard in one, two or three phases are provided in Table 3.8. These represent an average of 1 to 2 vessel movements per day during construction. In addition, the maximum number of vessels on site at any one time would be 57.

Table 3.8 Indicative Construction and Commissioning Vessel Movements

Vessel Type	1800MW installed as a single phase	900MW phase	Total for 2 x 900MW phases	600MW phase	Total for 3 x 600MW phases
Indicative total number of vessel movements	1130	565	1130	565	1695

3.3.6.2 Operation and Maintenance vessels

39. Indicative operation and maintenance (O&M) vessel movements are provided in Table 3.9.

Table 3.9 Indicative O&M Vessel Movements

Parameter	Number of movements
Indicative total number of vessel movements per year	480
Average number of movements per day	1-2

40. Once commissioned, the wind farm would operate for up to 25 years. All offshore infrastructure including wind turbines, foundations, cables and offshore substations would be monitored and maintained during this period in order to maximise efficiency.

3.3.7 Changes to prey resource

41. Changes to prey resource will be informed by the fish ecology impact assessment which will be based on the worst case scenarios for relevant fish receptors.

3.3.8 Decommissioning

42. Decommissioning is anticipated to result in the removal of accessible installed components comprising: all of the wind turbine components and part of the foundations (those above sea bed level). The inter-array cables and export cables are expected to be left *in situ*. The process for removal of foundations is generally the reverse of the installation process with no piling and possible cutting of foundations to an appropriate level below seabed level.

43. Possible effects on marine mammals associated with the decommissioning stage(s) will be considered as part of the HRA and a further assessment will be carried out

ahead of any decommissioning works to be undertaken taking account of known information at that time.

3.3.9 In-combination Scenarios

44. Advice from Natural England in June 2017 stated the following projects should be included in the in-combination assessment:

- Offshore wind farms:
  - Triton Knoll;
  - Hornsea Project One;
  - Hornsea Project Two;
  - Hornsea Project Three;
  - East Anglia ONE;
  - East Anglia THREE;
  - East Anglia ONE NORTH
  - East Anglia TWO;
  - Dogger Bank Creyke Beck A;
  - Dogger Bank Creyke Beck B;
  - Dogger Bank Teesside A;
  - Dogger Bank Teesside B;
  - Future possible works at Galloper (e.g. seismic survey);
- Oil and gas licence proposals, including any international licences;
- UXO clearance, including any international operations.

45. In addition to this list, Vattenfall is also developing the Norfolk Boreas offshore wind farm to the north of NV East, with the EIA following approximately a year behind the Norfolk Vanguard EIA.

46. The development of Norfolk Boreas will use the same offshore cable corridor as Norfolk Vanguard with the addition of a spur to the Norfolk Boreas site.

47. The full implications of the Norfolk Vanguard and Norfolk Boreas in-combination impact scenarios, as well as in-combination impacts with respect to these other existing and planned projects will be fully considered as part of the HRA process.

48. It is acknowledged that, given the fast moving nature of offshore development, it is likely that new projects relevant to the assessment will arise throughout the pre-application period and therefore in-combination screening will be ongoing. In order to finalise an assessment, it will be necessary to have a cut-off period after which no more projects will be included. It was agreed with the marine mammal topic group at the Evidence Plan meeting on 15th February 2017 that a reasonable cut-off point is the date of receipt of comments upon the Preliminary Environmental Information Report (PEIR).

3.4 Assessment of Potential Effects on the Southern North Sea cSAC

49. The HRA Screening, provided alongside this method statement, identifies that the following potential effects during construction, O&M and decommissioning of Norfolk Vanguard to be considered in the HRA process are:

- Underwater noise;
- Vessel interactions; and
- Indirect impacts through effects on prey species.

3.4.1 Underwater noise

50. The potential impacts of underwater noise on marine mammals are lethal injury, sub lethal physical injury, sub lethal auditory injury and behavioural disturbance. Should marine mammals be very close to the noise source, the high peak pressure sound levels have the potential to cause death, or severe injury leading to death. High exposure levels from underwater sound sources can also cause auditory injury; taking the form of a permanent loss of hearing sensitivity (Permanent Threshold Shift; PTS) or, a temporary loss in hearing sensitivity (Temporary Threshold Shift; TTS). Marine mammals may exhibit varying intensities of behavioural response at lower noise levels. The response can vary due to exposure level, the hearing sensitivity of the individual, context, previous exposure history or habitation, motivation and ambient noise levels (e.g. Southall *et al.* 2007).

51. The greatest potential impact associated with Norfolk Vanguard that could affect marine mammals is associated with underwater noise from pile driving and UXO clearance during construction. Subacoustech are undertaking underwater noise modelling based on the worst case propagation (maximum water depth) and a range of hammer energies (see Section 28).

52. As a result of the commitment to establish mitigation zones and other mitigation measures in the MMMP (see Section 3.3.1), the potential risk for any lethal effects, physical injury or auditory injury associated with underwater noise will effectively be mitigated and therefore have no potential to cause a LSE on the Southern North Sea cSAC. As a result, it is proposed that the assessment of effects from underwater noise only considers the effects arising from behavioural avoidance in accordance with the approach taken for other offshore wind farms, such as East Anglia THREE.

53. Behavioural reactions that may occur as a result of exposure to noise include, orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement / diving behaviour, temporary or permanent habitat abandonment (Southall *et al.* 2007).

54. It is considered that the potential range of disturbance impact from piling is up to 26km from the source of noise, based on the effective deterrent radius (EDR) for a single monopile (Tougaard *et al*, 2013). This is in accordance with JNCC (2017) and advice from Natural England in June 2017. The area associated with this impact range is assumed to be a circular area of 2,124km^2) and will be used to calculate the number of individuals potentially affected based on site specific mean density estimates.

55. The estimated number of animals affected will be considered against the management unit population and the cSAC population (17.5% of the management population) (see Section 3.2.1).

56. The potential disturbance impact area of 2,124km^2 per pile will be applied to locations within the NV East and NV West that represent the maximum and minimum potential overlap with the summer and winter cSAC areas.

57. As discussed in Section 28, up to four concurrent piling events (two in NV East and two in NV West) may be undertaken. There would be overlap of the 26km disturbance ranges for concurrent piling operations and therefore the overall area, taking into account this overlap, will be calculated based on the greatest overall overlap with the cSAC (see Figure 3.2).

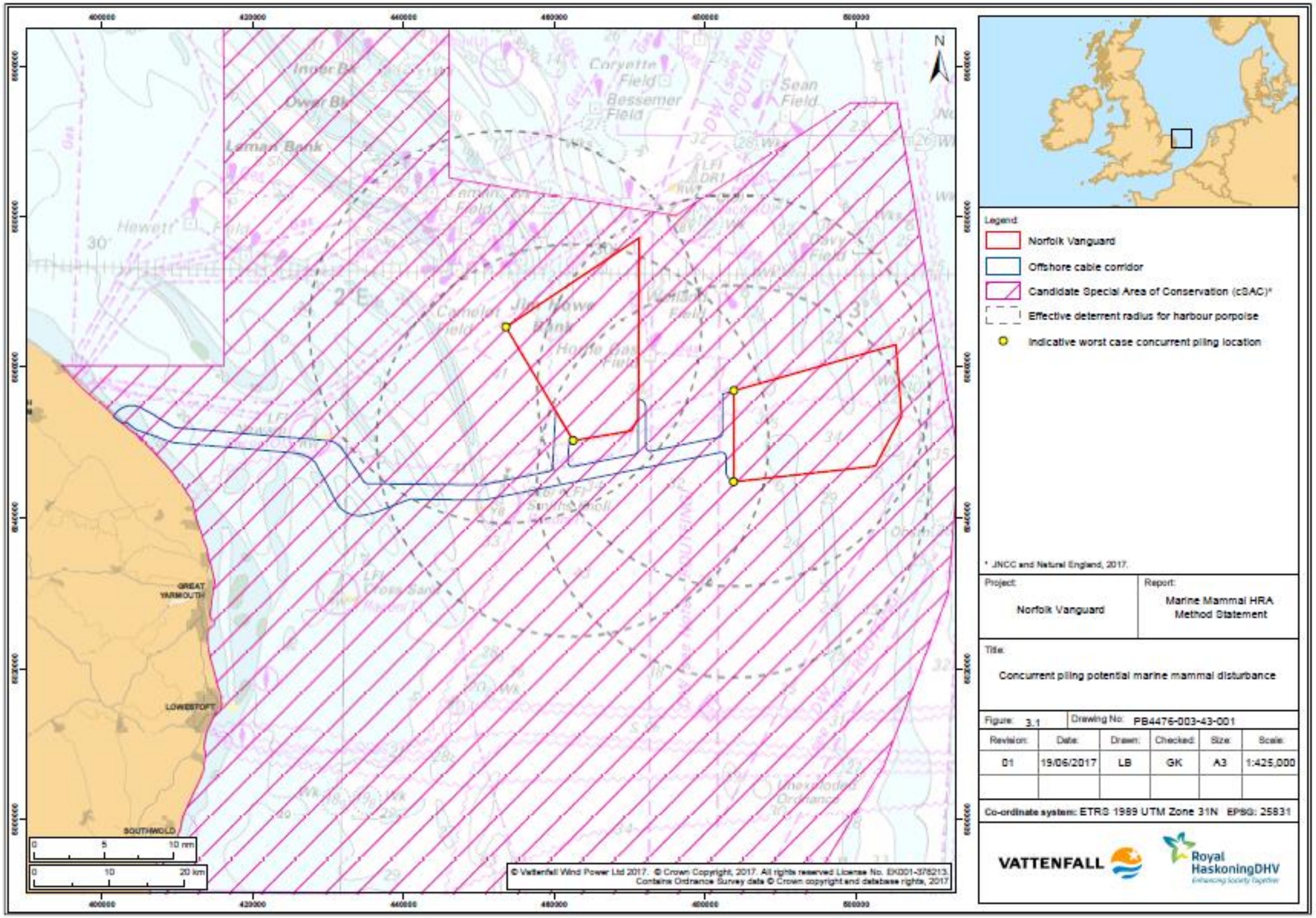

Figure 3.2: Disturbance impact ranges (26km) from concurrent piling operations

58. A behavioural disturbance range of 26km from UXO clearance will be assessed in the HRA in accordance with advice from Natural England in June 2017. The worst case scenario location within the Norfolk Vanguard offshore project area for a UXO clearance operation will be identified in relation to the maximum overlap with the cSAC.

59. Other noise sources such as vessel noise, seabed preparation, rock dumping, cable burial and operational noise from the wind turbines will be considered qualitatively based on expert judgement.

3.4.2 Vessel interaction

60. The construction and O&M ports to be used for Norfolk Vanguard are not yet known but may be a location on the east coast of England (Hull, Great Yarmouth or Lowestoft). Vessel movements to and from these ports will follow recognised routes. The increased risk for any vessel interaction is therefore assumed to be within the wind farm site and cable route, however this assumption will be reviewed using the results of the shipping and navigation EIA. The worst case of either the site specific density estimates or SCANS III density estimates for harbour porpoise will be used to calculate the number of harbour porpoise potentially at increased risk.

61. There is very little information on the collision rates or avoidance behaviour of harbour porpoise with vessels. However, it has been estimated from post mortem examinations within the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic (ASCOBANS) area (Evans *et al.* 2011) that approximately 4% of deaths recorded could be as a result of vessel strikes, based on evidence of physical trauma (blunt trauma or propeller cuts). In addition, Heinänen and Skov (2015) indicate a negative relationship between the number of ships and the distribution of harbour porpoises in the North Sea suggesting potential avoidance behaviour. Therefore the risk of collision is likely to be low and a precautionary 95% avoidance rate will be used in the assessment.

3.4.3 Changes to prey resource

62. Potential indirect impacts on harbour porpoise that may result through changes in prey species could include; changes in distribution, abundance and community structure of available prey, as well as increased competition with other marine mammal species and implications for reproductive success.

63. Construction activities have the potential to injure or to displace fish species that are sensitive to noise impacts and to increased sediment concentrations and sediment

re-deposition. This has potential to affect the food resource of marine mammals. This assessment will be informed by the Fish and Shellfish Ecology chapter of the PEIR/ Environmental Statement (ES), in particular the maximum range for potential disturbance based on the underwater noise modelling.

64. As with marine mammals, traumatic damage to fish as a result of piling noise will be mitigated, for example through soft-start procedures. Consequently displacement is likely to be the most evident impact on the prey resource.

65. The impact range and area will be considered against the site specific harbour porpoise density estimate (Section 3.2.1) to determine the potential number of harbour porpoise that could be affected. This is deemed to be a highly conservative approach as harbour porpoise distribution is likely to reflect prey distribution, therefore they would be expected to follow prey availability where prey are displaced. The temporary nature of the displacement (for the duration of the piling, see Section 3.3.5) will also be taken into consideration.

3.4.4 In-combination Assessment

66. The potential for projects to act in-combination on marine mammals will be considered in the context of the likely spatial and temporal extent of impacts. Publically available information will be reviewed to identify planned construction programmes and potential for temporal overlap with Norfolk Vanguard.

67. The assessment of cumulative impacts from other offshore wind farms will identify a worst case scenario location within each Agreement of Lease area that would result in the maximum overlap with the cSAC based on the following impact ranges:

- 26km disturbance range from pile driving;
- 10km from seismic surveys; and
- 26km from UXO clearance operations.

68. Consideration will also be given to the potential for concurrent piling within each wind farm.

69. There will be an inherent level of uncertainty associated with the in-combination assessment due to a combination of conservative assumptions and available programmes for projects that are in the planning stage being indicative. Assumptions and limitations will be discussed in the information to support HRA.

3.5 Assessment of effects of the Wash and North Norfolk Coast SAC

70. The HRA Screening, provided alongside this method statement, identifies that vessels associated with the construction, O&M and decommissioning of Norfolk

Vanguard could have an effect on harbour seal from the Wash and North Norfolk Coast SAC.

71. Distance of seal haul-out sites within the SAC in relation to the port and vessel routes will be determined to assess the potential for any increase in disturbance of seals at haul-out sites. However, all vessels will be using established routes and procedures; therefore the potential for any increase in disturbance should be minimal.

3.6 Assessment of effects of the Humber Estuary SAC

72. The HRA Screening, provided alongside this method statement, identifies that vessels associated with the construction, O&M and decommissioning of Norfolk Vanguard could have an effect on grey seal from the Humber Estuary SAC.

73. As discussed in Section 3.5, the distance of seal haul-out sites within the SAC in relation to the port and vessel routes will be determined to assess the potential for any increase in disturbance of seals at haul-out sites. However, all vessels will be using established routes and procedures; therefore the potential for any increase in disturbance should be minimal.

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