

Norfolk Boreas Offshore Wind Farm Offshore In Principle Monitoring Plan

(Version 3) (Clean)

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Glossary of Acronyms

AIS	Automatic Identification System
ALARP	As low as practically possible
DCO	Development Consent Order
DMLs	Deemed Marine Licences
DEPONS	Disturbance Effects on Harbour Porpoise of the North Sea
EAOW	The Consortium Company, East Anglia Offshore Wind Ltd
EIA	Environmental Impact Assessment
ES	Environmental Statement
GBS	Gravity Based Structure
HDD	Horizontal Directional Drilling
IPMP	In Principle Monitoring Plan
LAT	Lowest Astronomical Tide
MCA	Maritime and Coastguard Agency
MHWS	Mean High Water Spring
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MW	Megawatt
NRA	Navigation Risk Assessment
NSIP	Nationally Significant Infrastructure Project
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
O&M	Operation and maintenance
ORJIP	Offshore Renewables Joint Industry Programme
ORPAD	Offshore Renewables Protocol for Archaeological Discoveries
OWF	Offshore Wind Farm
ROV	Remote Operated Vehicle
SAC	Special Area of Conservation
SIP	Site Integrity Plan
SNCBs	Statutory Nature Conservation Bodies
SPR	ScottishPower Renewables
UXO	Unexploded Ordnance
VWPL	Vattenfall Wind Power Ltd
WSI	Written scheme of archaeological investigation
ZDA	Zone Development Agreement

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Landfall	Where the offshore cables come ashore at Happisburgh South
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore export cables	The cables which transmit power from the offshore electrical platform to the landfall.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Offshore service platform	A platform to house workers offshore and/or provide helicopter refuelling facilities. An accommodation vessel may be used as an alternative for housing workers.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard OWF sites.
Project interconnector search area	The area within which project interconnector cables would be installed.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
The Applicant	Norfolk Boreas Limited
The project	Norfolk Boreas Wind Farm including the onshore and offshore infrastructure.

1 INTRODUCTION

1.1 Purpose of the In Principle Monitoring Plan

1. This In Principle Monitoring Plan (IPMP) has been produced following consultation (including that undertaken as a part of the Norfolk Vanguard offshore wind farm project) with the Marine Management Organisation (MMO), relevant Statutory Nature Conservation Bodies (SNCBs), and other relevant parties (e.g. Historic England) in order to provide the basis for delivering the monitoring measures as required by the conditions contained within the Deemed Marine Licences (DMLs).
2. The IPMP provides a key mechanism through which the relevant regulatory authorities can be assured that required offshore monitoring activities associated with the construction and operation of the offshore infrastructure for the project will be formally controlled and mitigated.
3. The IPMP provides a framework to agree the exact detail for monitoring requirements (e.g. timings and methodologies) with the MMO, in consultation with relevant SNCBs and other parties (e.g. Historic England) post consent. Due to the long lead in time for the development of offshore wind farms it is not desirable or effective to provide final detailed method statements prior to being granted consent. However, agreeing guiding principles reinforces commitments made in the Environmental Statement (ES) and complements other requirements set out in the DMLs and will allow refinements to be made based on the best available knowledge and technology. Final detailed plans for monitoring work will be produced closer to the time that the actual work will be undertaken. The DMLs set out certain timescales in advance of commencement of the licensed activities, by when the IPMP must be submitted to the MMO for their approval.
4. The relevant topics and/or receptor groups that will be discussed in this plan are as follows. This is cross referenced against the relevant conditions within the respective DMLs in Appendix 1:
 - Marine Geology, Oceanography and Physical Processes;
 - Benthic Ecology;
 - Fish and Shellfish Ecology;
 - Marine Mammal Ecology;
 - Underwater Noise;
 - Offshore Ornithology;
 - Commercial Fishing;
 - Shipping and Navigation; and
 - Offshore Archaeology and Cultural Heritage.

1.2 Background

5. Norfolk Boreas Limited (an affiliate company of Vattenfall Wind Power Ltd (VWPL), ‘the Applicant’) is proposing to develop Norfolk Boreas, an offshore wind farm in the southern North Sea.
6. The Norfolk Boreas project comprises the Norfolk Boreas site, within which wind turbines, associated platforms and array cables will be located. The offshore wind farm will be connected to the shore by offshore export cables installed within the offshore cable corridor from the wind farm to a landfall point at Happisburgh South, Norfolk. From there onshore cables would transport power over approximately 60km to the onshore project substation near to the village of Necton, Norfolk. A full project description is given in the ES, Chapter 5 Project Description.
7. Norfolk Boreas Limited have included two scenarios within the Development Consent Order (DCO) application: Scenario 1 where the Norfolk Vanguard project and Norfolk Boreas proceed to construction; and Scenario 2 where Norfolk Vanguard does not. These two scenarios are presented in Chapter 5 Project Description of the ES (document reference 6.1.5). The two scenarios have not materially affected the drafting of this document as the monitoring procedures being proposed would be the same regardless of which ever scenario arises. However, it should be noted that if Norfolk Vanguard does not proceed (and if Norfolk Boreas does proceed under Scenario 2) then cables to connect Norfolk Boreas with Norfolk Vanguard (the “project interconnector” cables) would not be required. Therefore, under this scenario Schedule 13 (the Project Interconnector DML) of the DCO would not be required.
8. This document takes account of developments throughout the Norfolk Vanguard examination and this version has been updated in response to submissions made to the Norfolk Boreas Examination up until Deadline 4 (January 30th) and to take account of a commitment to reduce the maximum number of turbines within the Norfolk Boreas site to mitigate ornithological impacts (further information can be found in an Offshore Ornithology Assessment Update also submitted at Deadline 5 of the Norfolk Boreas Examination [ExA.AS-8.D5.V2] .
9. Should Norfolk Vanguard be constructed, any monitoring undertaken for that project which is relevant to the Norfolk Boreas project would be used to inform the final Norfolk Boreas Monitoring Plan. Norfolk Boreas Limited will endeavour to develop its survey timelines in such a way as to maximise the use of data and experience gathered by Norfolk Vanguard.
10. Once built, Norfolk Boreas would have an export capacity of up to 1,800MW, with the offshore components comprising:

- Wind turbines;
 - Offshore electrical platforms;
 - A service platform;
 - Met masts;
 - Lidar;
 - Array cables;
 - Inter-connector cables or project interconnector cables¹; and
 - Export cables.
11. The key onshore components of the project are as follows:
- Landfall;
 - Onshore cable route, accesses, trenchless crossing (e.g. Horizontal Directional Drilling (HDD)) zones and mobilisation areas;
 - Onshore project substation; and
 - Extension to the Necton National Grid substation and overhead line modifications.
12. The Norfolk Boreas site is located approximately 73km from the closest point of the Norfolk Coast. The site covers an area of approximately 725km².
13. The detailed design of Norfolk Boreas (e.g. numbers of wind turbines, layout configuration, foundation type and requirement for scour protection) would not be determined until post-consent. Therefore, realistic worst case scenarios in terms of potential impacts/effects are adopted to undertake a precautionary and robust impact assessment.
14. For Norfolk Boreas, several different sizes of wind turbine are being considered in the range of 11.55MW and 20MW. In order to achieve the maximum 1,800MW export capacity, there would be between 90 (20MW) and 158 (11.55MW) wind turbines.
15. In addition, up to two offshore electrical platforms, a service platform, two meteorological masts, two LiDAR platforms and two wave buoys, plus a network of up to 740km of offshore cables are considered as part of the worst-case scenario within the Norfolk Boreas site.

¹ There may be a requirement for cables to be placed within the project interconnector search area (Figure 5.1 of the ES) which would link the Norfolk Boreas project to the Norfolk Vanguard project (section 5.4.12 of ES Chapter 5 Project Description). Either “Interconnector cables” which would link platforms within the Norfolk Boreas site would be installed or “project interconnector cables” would be installed. Under no scenario would both be required.

16. Norfolk Boreas Limited is considering constructing the project in either a single phase of up to 1,800MW or in two phases (up to a maximum of 1,800MW). The layout of the wind turbines will be defined post consent.
17. The full construction window is expected to be up to three years for the full 1,800MW export capacity and offshore construction would be anticipated to commence around 2025. Chapter 5 Project Description provides indicative construction programmes for the single phase and two phase options.

Table 1.1 Key offshore project characteristics

Parameter	Characteristic
Export Capacity	Up to 1,800MW
Lease period	50 years
Indicative construction window	3 years (preceded by up to 1 year pre-construction work)
Anticipated design life	Approx. 30 years
Number of wind turbines	Between 90 and 158 turbines ranging from 11.55MW to 20MW.
Norfolk Boreas site area	725km ²
Offshore cable corridor area	226km ²
Project interconnector search area	276km ²
Project interconnector search area	269km ²
Water depth Norfolk Boreas site (LAT)	Between 20.4m and 42.8m
Distance from Norfolk Boreas site to shore (closest point of site to the coast)	73km
Maximum number of export cables	Four (laid as pairs in two trenches)
Maximum turbine rotor diameter	303m
Maximum hub height above HAT	198.5m
Maximum tip height above HAT	350m
Maximum offshore cable corridor length	100km
Maximum length of export cables	500km (400 within the offshore cable corridor and 100 within the Norfolk Boreas site)
Maximum total export cable trench length	250km (Based on a total of 4 cables, with cables laid in pairs)
Maximum array cable length	600km
Maximum number of interconnector cables (between platforms located within the Norfolk Boreas site).	3 (a pair of HVDC cables in one trench and a single AC cable in a second trench)*.
Maximum number of project interconnector cables (between an offshore electrical platform or turbines within the Norfolk Boreas site and an electrical	11 (a pair of HVDC cables in one trench and a single AC cable in a second trench and 8 AC array cables *.

Parameter	Characteristic
platform within the Norfolk Vanguard site)	
Maximum length of interconnector cable trenching (which would be installed within the Norfolk Boreas site)	90km (a pair of HVDC cables in one trench and a single AC cable in a second trench. Therefore 60km of trench)*.
Maximum length of project interconnector cable installed within the project interconnector search area	120km of cable A maximum of 92km of cable trench*.
Minimum turbine clearance above sea level	30m (Mean High Water Springs)
Indicative minimum separation between turbines	In row and inter row spacing 800m
Wind turbine foundation type options	<ul style="list-style-type: none"> • Piled monopile; • Suction caisson monopile; • Piled tripod or quadropod; • Suction caisson tripod or quadropod; • Gravity Base; and • TetraBase
Maximum number of met masts	Up to two
Maximum height of met masts above Highest Astronomical Tide (HAT)	200m
Met mast foundation type options	<ul style="list-style-type: none"> • Piled monopile; • Suction caisson monopile; • Piled tripod or quadropod; • Suction caisson tripod or quadropod; and • Gravity Base.
Maximum number of offshore electrical platforms	<ul style="list-style-type: none"> • Up to two
Maximum number of offshore service platforms	<ul style="list-style-type: none"> • One
Topside maximum height of offshore electrical platforms above HAT	<ul style="list-style-type: none"> • 100m
Topside maximum height of offshore service above HAT	<ul style="list-style-type: none"> • 100m
Offshore platform (electrical and service) foundation type options	<ul style="list-style-type: none"> • Six legged jacket -piled; • Six legged Jacket - suction caissons • Four legged jacket -piled • Four legged jacket suction caissons. • Gravity base
Buoys	<ul style="list-style-type: none"> • Up to two LiDAR, two wave buoys and a number (to be determined in consultation with the MCA and Trinity house post consent) of navigational buoys would be deployed.

* Either “Interconnector cables” would be installed or “project interconnector cables” would be installed. Under no scenario would both be required.

2 GENERAL GUIDING PRINCIPLES FOR THE PROPOSED MONITORING

18. Throughout the ES and supporting documentation the Applicant has taken steps to avoid or reduce significant impacts either through the iterative process of project design ('embedded mitigation' e.g. the location of project boundaries) or by 'additional' mitigation measures which will be applied during the construction, operation and maintenance (O&M) or decommissioning phases of the Project.
19. The guiding principles for monitoring and which apply in general to the in principle monitoring outlined in this document are as follows:
 - a. All consent conditions, which would include those for monitoring, should be "necessary, relevant to planning, relevant to the permitted development, enforceable, precise and reasonable in all other respects" as set out in Paragraph 206 of the National Planning Policy Framework and referred to as the 'six tests' (Department for Communities and Local Government, 2018).
 - b. In line with good practice, monitoring must have a clear purpose in order to provide answers to specific questions (e.g. Cefas, 2012, Glasson et al., 2011, OSPAR, 2008). As such, monitoring proposals should have an identified end date and confirmed outputs, which provide statistically robust data sets, as applicable to the hypothesis being tested.
 - c. Monitoring should be targeted to address significant evidence gaps or uncertainty, where there is potential for a significant environmental impact
 - d. Proposals for monitoring should be based, where relevant, on the best practice and outcomes of the latest review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms (MMO, 2014).
 - e. The scope and design of all monitoring work should be finalised and agreed following review of the results of any preceding survey and/or monitoring work (i.e. an adaptive approach), including those surveys conducted in support of the environmental impact assessment. This includes the potential for survey requirements to be adapted based on the results of the monitoring outlined in this document.

3 NORFOLK BOREAS RESIDUAL IMPACTS

20. The Environmental Impact Assessment (EIA) predicts the residual impact to a species or features taking into account:
 - Linkages using the source > pathway > receptor model;
 - Embedded / Additional Mitigation;
 - Sensitivity to the effect;
 - Magnitude of the effect; and
 - Ecological / economic importance.
21. For each receptor, the residual impacts and key areas of uncertainty as predicted within the Norfolk Boreas ES are outlined in section 4.
22. The significance of the residual impact should not in its own right necessarily lead to the requirement for monitoring. Monitoring should be targeted to address significant evidence gaps or uncertainty, where there is potential for significant environmental impact.

4 IN PRINCIPLE PROPOSALS FOR MONITORING

23. The following sections set out the in principle proposals for monitoring in relation to those topics and/or receptor groups assessed in the ES. Appendix 1 provides cross references to the relevant conditions within the respective DMLs.
24. While accepting that this IPMP represents the best approach to monitoring available at the time of writing, it is recognised that the outcomes of the survey work discussed could influence future monitoring requirements, methodologies, focus and effort for the project, as knowledge and understanding develops. For example, where appropriate, and in consultation with the MMO and relevant SNCBs, these scopes may be refined to consider other relevant studies carried out by neighbouring projects such as Norfolk Vanguard and East Anglia THREE. This is a key principle for an adaptive approach to monitoring and will be the subject of ongoing consultation between the Applicant, the MMO and relevant SNCBs. It is recognised that the MMO has the ability to vary the DML conditions in this regard.
25. This document will be used as a basis for further discussions post consent.

4.1 Engineering and Design Related Monitoring

26. In addition to the environmental survey and monitoring required as conditions of the DMLs within the Development Consent Order (DCO), additional studies will be undertaken for the project for engineering and design purposes. Some of these will overlap with the conditioned monitoring and wherever possible the Applicant will look to combine surveys for monitoring purposes with those already being carried out for engineering purposes. Examples of these surveys are:
 - Geophysical;
 - Geotechnical;
 - Unexploded ordnance (UXO) survey and clearance; and
 - Cable burial survey.

4.2 Marine Geology Oceanography and Physical Processes

4.2.1 Conclusions of the Environmental Statement

27. The ES concludes no impact would be greater than negligible significance for the project alone or cumulatively.
28. At the landfall, the Horizontal Directional Drills (HDDs) will exit at offshore locations, away from the beach, seaward of the low water mark. Cable protection at each exit point is likely to consist of one mattress (6m long, 3m wide and 0.3m high) and rock protection (up to 5m long, 5m wide and 0.5m high). The cables themselves would be buried at the landfall throughout the operational life of the project. This design

would have limited effect on bedload sediment transport, and hence the magnitude of effect predicted in the ES is negligible, with no impact predicted on the East Anglian coast morphological receptor.

4.2.2 In Principle Monitoring

29. The Applicant would propose to undertake a post construction survey of the offshore and nearshore area(s) within the order limits using appropriate high resolution bathymetric and side-scan equipment (required under Condition 20(2)(b) of the Schedules 9 and 10 (Generation DMLs), Condition 15(2)(b) of Schedules 11 and 12 (Transmission DMLs) and Condition 13(3)(b) of Schedule 13 (the Project Interconnector DML) of the DCO). This information would also help inform the interpretation of the benthic monitoring campaign (see section 4.3).
30. Monitoring of the section of the offshore cable corridor which overlaps with the Haisborough, Hammond and Winterton Special Area of Conservation (SAC) will be addressed in the Haisborough, Hammond and Winterton (HHW) SAC Site Integrity Plan (SIP) required under Condition 9(1)(m) of Schedules 11 and 12 of the DCO in accordance with the Outline Haisborough, Hammond and Winterton SAC SIP (document reference 8.20).
31. Norfolk Boreas Limited does not expect to undertake sandwave levelling in the nearshore area as there are no significant sandwaves in that area. However, should dredging of sandwaves be required within 2km of the coast an appropriate sediment sampling regime would be agreed with the MMO and included in a relevant monitoring Plan.
32. The following table provides information on the monitoring requirements for marine physical processes. The proposed monitoring will be discussed and agreed with the MMO in consultation with the relevant Statutory Nature Conservation Body (SNCB).

Table 4.1 In principle monitoring proposed – Marine Geological and Physical Processes

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
Changes in seabed topography, including scour processes	Physical environment and lined receptor groups e.g. marine ecology	Pre-construction	<ul style="list-style-type: none"> • Engineering and design purposes • Input in to benthic and other related ecological surveys and monitoring requirements as agreed with the MMO in consultation with SNCBs 	A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric undertaken to IHO S44ed5 Order 1a standard and side-scan surveys of the area(s) within the order limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The “site of each works” being the area within the order limits which is actually taken forwards to construction noting that it is possible that certain areas within the order limits may not be developed.)	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs.
		Post-construction	<ul style="list-style-type: none"> • Structural integrity / engineering (scour) • Cable burial • Monitoring of recovery of Annex I Sandbanks at the location of pre-sweeping (if used) within the Haisborough, Hammond and Winterton SAC – details to be addressed in the Haisborough, Hammond and Winterton SAC SIP (outline version provided at document reference 8.20) 	A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric surveys undertaken to IHO S44ed5 Order 1a standard and side scan sonar surveys around appropriate samples of adjacent infrastructure to assess any changes in seabed topography. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment (which takes account of all factors which	

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
				<p>influence scour) to identify the sample of adjacent turbines with greatest potential for scour. The survey will be used to validate the desk based assessment: Further surveys may be required at a frequency to be agreed with the MMO (e.g. 3 years non-consecutive e.g. 1, 3 and 6 years or 1, 5 and 10 years). If evidence of recovery is recorded and agreed with the MMO, monitoring will cease.</p> <p>The quantity of turbines subject to monitoring will be confirmed following the completion of detailed design studies and in consultation with the MMO and relevant SNCBs.</p>	

4.3 Benthic and Intertidal Ecology

4.3.1 Conclusions of the Environmental Statement

33. The ES concludes no impact would be greater than minor adverse for the project alone or cumulatively. The offshore cable corridor runs through the Haisborough, Hammond and Winterton SAC Annex I Sandbanks and potential *Sabellaria spinulosa* reef was recorded during the site specific surveys (Fugro, 2016).

4.3.2 In Principle Monitoring

34. The following table provides information on the monitoring requirements for benthic ecology. Pre-construction and post-construction surveys would be targeted to areas where construction activities are planned and where there is deemed to be potential for Annex I habitats based on relevant available data. Monitoring of the section of the offshore cable corridor which overlaps with the Haisborough, Hammond and Winterton SAC would be addressed in the Haisborough, Hammond and Winterton SAC SIP required under Condition 9(1)(m) of Schedules 11 and 12 of the DCO, in accordance with the Outline Haisborough, Hammond and Winterton SAC SIP (document reference 8.20).
35. The proposed monitoring will be discussed and agreed with the MMO in consultation with the relevant SNCB. Where possible, synergies with monitoring commitments made in sections 4.1 and 4.2 would be explored in interpreting geophysical data. If, at the time of completion of the final detailed plan, there is good, evidence based, justification for increasing the scope of the benthic surveys to include other benthic monitoring techniques then this will be agreed with the MMO and included within the final plans.
36. Further to the commitments outlined above and in Table 4.2, Norfolk Boreas Limited have committed to undertaking an interim survey in 2020 to map the presence and extent of *S.spinulosa* reef. Further detail of this survey can be found in section 4.2.1 of the Outline Norfolk Boreas Haisborough Hammond and Winterton Special Area of Conservation Site Integrity Plan (document reference 8.20). The results of this survey will inform the final Monitoring Plan.

Table 4.2 In principle monitoring proposed – Benthic Ecology

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
Effects on <i>Sabellaria spinulosa</i> reef	<i>S. spinulosa</i> reef	Pre-construction	Determine the location and extent of any <i>S. spinulosa</i> reef within areas of the order limits in which it is proposed to carry out construction works to inform the appropriate mitigation if found	<ul style="list-style-type: none"> A single geophysical (sidescan and Multi-Beam Echo Sounder, used simultaneously) survey of those areas within which it is proposed that seabed works will be carried out at a resolution sufficient to identify potential <i>S. spinulosa</i> reef; and In areas where potential <i>S. spinulosa</i> reef is identified from the review of the geophysical data, further survey e.g. drop down video will be deployed to confirm presence, extent and elevation. The methodology and extent of the survey within the Haisborough Hammond and Winterton SAC will be agreed with the MMO and Natural England through the HHW SIP refinement process 	<ul style="list-style-type: none"> Survey programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs. Surveys may occur up to 12 months prior to the proposed construction works The Applicant has submitted an Outline SIP as part of the DCO submission, a final SIP will be submitted in accordance with the timescales required by the DMLs.
		Post-construction	The requirement for post-construction monitoring will be dependent on the findings of the pre-construction surveys.	<ul style="list-style-type: none"> A survey to determine any change in the location, extent and composition of any benthic habitats of conservation, ecological and/or economic importance constituting Annex I reef habitats identified in the pre-construction survey in the parts of the Order limits in which construction works were carried out. The survey design must be informed by the results of the pre-construction benthic survey. Where no <i>S. spinulosa</i> reef is identified by the pre-construction geophysical survey of the proposed works (and associated buffers), no further post-construction surveys will be undertaken; Where <i>S. spinulosa</i> reef is identified during the baseline survey and cannot be entirely 	<ul style="list-style-type: none"> If required, survey programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs. The survey will be conducted within the first year post commissioning of the proposed wind farm. If significant impacts are observed the potential requirement for further surveys will be agreed with the MMO following review of the post-construction survey. The Applicant has submitted an Outline HHW SIP as part of the DCO submission and a final HHW SIP will be

				<p>avoided through micro-siting, a single post-construction survey(s) will be undertaken, at a frequency to be agreed with the MMO (e.g. 3 years non-consecutive e.g. 1, 3 and 6 years or 1, 5 and 10 years). If evidence of recovery is available and agreed with the MMO, monitoring will cease. Surveys will specifically targeting those reefs identified in the baseline survey will be undertaken as a check on their condition using the same methodology set out for pre-construction monitoring to be agreed with the MMO</p>	<p>submitted in accordance with the timescales required by the DMLs.</p>
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4.4 Fish and Shellfish Ecology

4.4.1 Conclusions of the Environmental Statement

37. Alone and cumulatively, no moderate or major residual impacts are predicted for Norfolk Boreas.

4.4.2 In Principle Monitoring

38. The Applicant has considered the Guiding Principles set out in section 2 (specifically (b) and (c) and in the case of fish and shellfish ecology it is proposed that no further monitoring or independent surveys are required. As explained in section 4.3.2, if at the time of completion of the final detailed plans there is good, evidence based justification for increasing the scope of the benthic surveys this will be agreed with the MMO and included within the final plans. If a scope increase for the benthic surveys includes sediment sampling within the windfarm site, the data from that survey could be used to better understand any changes in habitat suitability for sandeels. This methodology for undertaking such a study would be agreed with the MMO through the final plans.
39. Underwater noise monitoring (section 4.6) is of relevance to Fish Ecology and if, in the opinion of the MMO, the assessment shows significantly greater impacts to those assessed in the ES, further consideration would be given to Monitoring and Mitigation for Fish Ecology, where appropriate.

4.5 Marine Mammals

4.5.1 Conclusions of the Environmental Statement

40. At the project level, impacts from Norfolk Boreas are assessed as negligible or minor adverse as a result of construction, operation and decommissioning. However, when the assessment considered other offshore wind farms that could be constructed at the same time, there is potential for significant cumulative impacts prior to mitigation for harbour porpoise and grey seal as a result of all underwater construction noise, including piling. The Norfolk Boreas contribution to the overall cumulative impact from underwater noise, during single pile installation, would potentially be the disturbance of up to 2,251 harbour porpoise, approximately 13.6% of the total 16,579 harbour porpoise that could be disturbed; the disturbance of up to two grey seal, approximately 0.1% of the total of 1,464 grey seal that could be disturbed; and the disturbance of 0.2 harbour seal, approximately 0.1% of the 251 harbour seal that could be disturbed.
41. An Outline Marine Mammal Mitigation Protocol (MMMP) and an In Principle Norfolk Boreas southern North Sea SAC SIP is provided with this DCO application (document reference 8.13 and 8.17). These are required to be finalised and submitted to the

MMO under Conditions 14(1)(f) and 14(1)(m) Schedules 9 and 10 and Condition 9(1)(f) and 9(1)(l) of Schedules 11 and 12 of the DCO. The documents form the framework for developing and agreeing mitigation and monitoring measures, with the SIP focussing on reducing the potential disturbance in relation to the Southern North Sea SAC. In order to address the overall cumulative impact, Norfolk Boreas Limited is committed to working with SNCBs, the MMO and other developers to establish a possible strategic approach to mitigation and monitoring.

4.5.2 In Principle Monitoring

42. As recognised by the MMO (2014), monitoring should be targeted to address significant risk, evidence gaps or uncertainty, which are relevant to the project and can be realistically filled (section 2 (c)). Given the small contribution that Norfolk Boreas has to impacts on marine mammals there may be little purpose or advantage in any site specific monitoring and therefore a strategic approach may be more appropriate in providing answers to specific questions where significant environmental impacts have been identified at a cumulative/in-combination level. If a strategic approach is adopted, the methodology and reporting requirements would be agreed with the MMO to ensure the requirements for Norfolk Boreas are delivered.
43. VWPL (the parent company of Norfolk Boreas Limited) has played a leading role in the Disturbance Effects on Harbour Porpoise of the North Sea (DEPONS) project and is supportive of other industry initiatives such as the Offshore Renewables Joint Industry Programme (ORJIP).
44. At the time of finalisation of the monitoring plan prior to construction, consideration would be given to any wider benefits from additional surveys as appropriate within the Order limits of Norfolk Boreas or in the wider Southern North Sea.
45. In addition, underwater noise monitoring (section 4.6) is of relevance to Marine Mammals and if, in the opinion of the MMO, the assessment shows significantly greater impacts to those assessed in the ES, further consideration will be given to Monitoring and Mitigation for marine mammals.
46. Norfolk Boreas Limited will follow the latest relevant guidelines and scientific evidence at the time, in relation to a strategic approach to construction and monitoring in development of the MMMP and SIP. A draft MMMP (document reference 8.13) and In Principle SIP (document reference 8.17) are provided with the DCO application, which will be finalised prior to construction with input from the contractor and in agreement with the MMO in consultation with the SNCBs.

Table 4.3 In principle monitoring proposed – Marine Mammals

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
Disturbance effects on harbour porpoise	Harbour porpoise	Construction	Ensure best practice is followed to minimise risk of injury or death to marine mammals	<ul style="list-style-type: none"> The Applicant will follow the relevant guidelines at the time in relation to a strategic approach to construction and monitoring in the development of the MMMP and Southern North Sea SAC SIP. The particulars of deployment will be determined subsequent to appointment of the contractor in the pre-construction stage and with consideration of best available techniques at that time. 	<ul style="list-style-type: none"> The Applicant has submitted and agreed a draft MMMP as part of the Application submission. The DMLs set out certain timescales in advance of commencement of the licensed activities, by when the MMMP and SIP must be submitted to the MMO for their approval

4.6 Underwater Noise

4.6.1 Conclusions of the Environmental Statement

47. There is variability and uncertainty in the extent of underwater noise impacts due to the range of threshold criteria used in the assessment (as requested by SNCBs).
48. In addition, varying seabed bathymetry, maximum piling hammer energies and proposed pile sizes provide variability in the impact ranges. Data from previous monitoring of 7m diameter piles, the largest where measured data is available, have been used for the monopile modelling and piles of approximately 4m diameter were used in the pin-pile modelling. The modelling considers the frequency content associated with pile sizes based on available data² and assumes the trends would continue to the larger piles of up to 15m diameter under consideration for the monopiles at Norfolk Boreas.

4.6.2 In Principle Monitoring

49. Construction noise monitoring would be required if piled foundations are used (in accordance with Condition 19(2) of Schedules 9 and 10 and Condition 14(2) of Schedules 11 and 12 of the DCO. Monitoring would include measurements of noise generated by the installation of the first four piled foundations of each piled foundation type to be installed in order to validate the assumptions made within the ES.
50. Noise measurements will be made in line with Good Practice Guide (2014) – Deployment for noise measurement and full specifications will be provided in the final monitoring plan.
51. Underwater data will be recorded in a format that allows comparison with the EIA underwater noise modelling with analysis using un-weighted metrics, such as peak sound pressure level, sound exposure level and peak to peak pressure level. All conclusions and discussions will be made in relation to the un-weighted metrics.
52. In addition, the requirements of the UK Marine Noise Register will be adhered to. This would cover registering geophysical survey activities (see section 4.1) as well as impact pile driving.

² Monopiles contain more low frequency content and the pin piles contain more high frequency content due to the dimensions and acoustics of the pile

Table 4.4 In principle monitoring proposed – Underwater Noise

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
Injury / disturbance to marine ecology	Marine ecology	Construction	Reduce uncertainty in impact assessment	If piled foundations are used during the construction of Norfolk Boreas: Compare the measured data, from the first four piles of each type (e.g. monopile or pin-pile), with predictions for received levels, source levels that were made in the ES. A Sound Exposure Level plot based on the noise modelling in the ES will be produced and agreed with the MMO prior to construction to allow comparison of the ES predictions and measured data during construction.	<p>Survey programmes and methodologies for the purposes of monitoring must be submitted to the MMO for written approval in accordance with the timescales required by the DMLs. Information will also be gathered and processed in accordance with UK Noise Registry requirements if appropriate at the time of construction.</p> <p>The results of the initial noise measurements must be provided to the MMO within four weeks of the installation of the first four piled foundations of each piled foundation type. The assessment of this report by the MMO will determine whether any further noise monitoring is required. If, in the opinion of the MMO in consultation with the relevant SNCB, the assessment shows significantly different impacts to those assessed in the ES or failures in mitigation, all piling activity must cease until an update to the MMMP and further monitoring requirements have been agreed.</p>

4.7 Offshore Ornithology

4.7.1 Conclusions of the Environmental Statement

53. At the project level, impacts from Norfolk Boreas are assessed as negligible or minor adverse as a result of construction, operation and decommissioning.
54. The cumulative assessment identified that most impacts would be temporary, small scale and localised. Given the distances to other activities in the region (e.g. other offshore wind farms and aggregate extraction) and the highly localised nature of the potential impacts, it is concluded that there is no pathway for interaction between most impacts cumulatively.
55. The cumulative collision risk impact and displacement impact assessment determined that the risk to birds is no greater than minor adverse significance for all species.

4.7.2 In Principle Monitoring

56. Vattenfall (as the parent company of Norfolk Boreas Limited) have a proven commitment to ornithological monitoring of offshore wind farms and improving understanding of potential impacts (e.g. through the European Offshore Wind Deployment Centre research projects) and will maintain this commitment in relation to Norfolk Boreas.
57. The aims of monitoring should be to reduce uncertainty for future impact assessment and address knowledge gaps. To this end, Norfolk Boreas Limited will engage with stakeholders and the methodology would be developed initially through an outline plan and later through the Ornithological Monitoring Plan as required under Condition 14(1)(l)(i) and (ii) of Schedule 9 and 10 of the DCO.
58. As for marine mammals (section 4.5), there may be little purpose or advantage in any site specific monitoring for ornithology and therefore a strategic approach may be more appropriate in providing answers to specific questions where significant environmental impacts have been identified at a cumulative/in-combination level. Aspects for consideration will include post-construction monitoring of collision risks (e.g. improvements to modelling, options for mitigation and reduction), displacement (e.g. understanding the extent and consequences of displacement) and improving reference population estimates and colony connectivity.

4.8 Commercial Fisheries

4.8.1 Conclusions of the Environmental Statement

59. The impacts on commercial fisheries during the construction, operation and decommissioning phases of Norfolk Boreas alone would be of negligible or minor adverse residual significance to commercial fisheries. Moderate cumulative impacts with other projects were identified for loss or restricted access to traditional fishing grounds to Dutch and UK beam trawler and Dutch seine netter receptors.

4.8.2 In Principle Monitoring

60. An Outline Fisheries Liaison and Co-existence Plan is provided with this DCO application (document reference 8.19). The final plan is secured through Condition 14(1)(d)(v) of Schedule 9 and 10; Condition 9(1)(d)(v) of the of Schedule 11 and 12 and Condition 7(1)(d)(v) of Schedule 13 of the DCO to ensure relevant fishing fleets are notified of commencement of licensed activities and to address the interaction of the licensed activities with fishing activities, as described in the Outline Plan. No further monitoring of commercial fisheries is proposed.

4.9 Shipping and Navigation

4.9.1 Conclusions of the Environmental Statement

61. The effects of the project have been assessed in Chapter 15 of the ES and in the Navigation Risk Assessment (Appendix 15.1 of the ES), with impacts ranging from ‘no perceptible effect’ to ‘tolerable with mitigation/as low as reasonably possible (ALARP)’.

4.9.2 In Principle Monitoring

62. Vessel traffic monitoring would be required using Automatic Identification System (AIS) equipment during both construction Condition 19 (4) of the Schedules 9 and 10 and operation Condition 20 (2)(d) of Schedules 11 and 12 as specified in the Outline Navigation Monitoring Strategy (document reference 8.18). Table 4.5 provides information on the vessel traffic monitoring requirements for shipping and navigation.

Table 4.5 In principle monitoring proposed – Shipping and Navigation

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
Effects on the levels of marine traffic across the project	Marine traffic	Construction	Validate the predictions made in the Environmental Statement and Navigation Risk Assessment with respect to potential effects on the levels of shipping traffic.	Construction monitoring shall include vessel traffic monitoring by Automatic Identification System (AIS), including the provision of reports on the results of that monitoring periodically as requested by the Maritime and Coastguard Agency (MCA).	Post-construction vessel traffic monitoring using AIS will be undertaken for a maximum of 28 days, although not necessarily consecutive, and will take account of seasonal variation of traffic patterns over a year. This will be done at a suitable time as agreed with the MMO in consultation with the MCA and Trinity House following the commencement of commercial operation.
		Post-construction		Vessel traffic monitoring by AIS, totalling a maximum of 28 days taking account of seasonal variations in traffic patterns over one year, following the commencement of commercial operation. A report will be submitted to the MMO, the MCA and Trinity House following the end of the monitoring.	

4.10 Offshore Archaeology and Cultural Heritage

4.10.1 Conclusions of the Environmental Statement

63. The construction, operation and decommissioning phases of Norfolk Boreas would result in a range of effects upon the marine archaeological and cultural heritage environment. For the project alone the effects that have been assessed are anticipated to be minor adverse or negligible on the basis of embedded mitigation. Furthermore, known archaeological receptors are not considered to be subject to significant cumulative impacts on the basis that they would be avoided where possible due to appropriate mitigation.

4.10.2 In Principle Monitoring

64. The following table provides information on the monitoring requirements for marine archaeology and cultural heritage. The principal mechanism for delivery of monitoring is through agreement on the offshore Written Scheme of Investigation (WSI). This includes the requirement for a pre-commencement WSI (offshore) to cover pre-commencement surveys and archaeological investigations which involve intrusive seabed works under Condition 14(2) of Schedules 9 and 10; Condition 9(2) of the Schedules 11 and 12 and Condition 7(2) of Schedule 13 of the DCO. The requirement for a pre-construction WSI is secured under Condition 14(1)(h) of Schedules 9 and 10; Condition 9(1)(h) of the Schedules 11 and 12 and Condition 7(1)(g) of Schedule 13 of the DCO) and will be agreed with the MMO in consultation with Historic England. An Outline WSI (document reference 8.6) has been submitted with the DCO application.

Table 4.6 In principle monitoring proposed – Offshore Archaeology and Cultural Heritage

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
All direct and indirect effects on the archaeological resource	All Archaeology receptors	Pre-construction	To inform selection of appropriate mitigation.	<p>An Outline offshore WSI has been compiled which makes provision for all archaeological mitigation that might be required in the light of pre-commencement and pre-construction investigations, including the archaeological assessment of marine survey data, reporting, archiving and dissemination of results. The WSI will be updated and finalised post-consent in consultation with Historic England to take account of any specific survey consideration or updates to design.</p> <p>Pre-commencement and pre-construction surveys will include swath-bathymetric surveys and side-scan surveys of the area(s) within the order limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. This should include the investigation and identification of seabed features of known (A1) and potential (A2) archaeological interest within the survey areas and which may require the refinement, removal or introduction of archaeological exclusion zones and to confirm project specific micrositing requirements. Where possible, this will be combined with geophysical surveys required for other receptors (see sections 4.1, 4.2 and 4.3).</p>	<p>Norfolk Boreas Limited has submitted an Outline WSI with the DCO application. Final pre-commencement and pre-construction WSIs will be submitted to the MMO for written approval in accordance with the timescales required by the DMLs</p> <p>As stated in the Outline WSI (offshore) (Document reference 8.6) <i>Historic England will be consulted on the scope of all further geophysical surveys undertaken for the project in order to ensure that the data generated are sufficiently robust to meet these archaeological objectives and to enable professional archaeological interpretation and analysis.</i></p>

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
All direct and indirect effects on the archaeological resource	All Archaeology receptors	Construction	To allow appropriate mitigation.	Specific requirements relating to monitoring during construction (including a conservation programme for finds) as detailed in the WSI. Notably the Offshore Renewables Protocol for Archaeological Discoveries (ORPAD) shall be followed during all intrusive works	The WSI will be submitted to the MMO for written approval in accordance with the timescales required by the DMLs.

5 REFERENCES

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APPENDIX 1: RELEVANT DML CONDITIONS

Subject	Relevant DML Condition				
	Schedule 9 Generation Licence – Phase 1	Schedule 10 Generation Licence – Phase 2	Schedule 11 Transmission Licence – Phase 1	Schedule 12 Transmission Licence – Phase 2	Schedule 13 Project interconnector search area
Marine geological and physical processes bathymetric (Pre-construction)	18(2)(b)	18(2)(b)	13(2)(b)	13(2)(b)	11 (1)(b)
Marine geological and physical processes bathymetric (Post-construction)	20(2)(b)	20(2)(b)	15(2)(b)	15(2)(b)	13 (1)(b)
Benthic <i>S. spinulosa</i> reef (Pre-construction)	18(2)(a)	18(2)(a)	9(1)(m) 13(2)(a)	9(1)(m) 13(2)(a)	11(2)(a)
Benthic <i>S. spinulosa</i> reef (Post-construction)	20(2)(a)	20(2)(a)	15(2)(a)	15(2)(a)	13(2)(a)
Marine mammals/ MMMP (Construction)	14(1)(f) 19(5)	14(1)(f) 19(5)	9(1)(f) 14(3)	9(1)(f) 14(3)	Not required as no piling permitted within this DML
Offshore ornithology/OMP (Pre-construction)	14(1)(l) 18(2)(c)	14(1)(l) 18(2)(c)	N/A	N/A	N/A
Offshore ornithology/OMP (Post-construction)	14(1)(l) 20(2)(c)	14(1)(l) 20(2)(c)	N/A	N/A	N/A
Piling underwater noise (Construction)	19(1)	19(1)	14(1)	14(1)	N/A
Shipping and navigation (Construction)	19(4)	19(4)	N/A	N/A	N/A
Shipping and navigation (Post-construction)	20(3)	20(3)	N/A	N/A	N/A

Subject	Relevant DML Condition				
	Schedule 9 Generation Licence – Phase 1	Schedule 10 Generation Licence – Phase 2	Schedule 11 Transmission Licence – Phase 1	Schedule 12 Transmission Licence – Phase 2	Schedule 13 Project interconnector search area
Archaeology and cultural heritage (during construction)	14(1)(h)(v)	14(1)(h)(v)	9(1)(h)(v)	9(1)(h)(v)	7(1)(g)(v)
Archaeology and cultural heritage (post -construction)	14(1)(h)(v)	14(1)(h)(v)	9(1)(h)(v)	9(1)(h)(v)	7(1)(g)(v)