

Hornsea Project Three
Offshore Wind Farm



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Appendix 2 to Deadline I submission – In-Principle Monitoring Plan V2.0

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Author	GoBe Consultants Ltd		
Checked by	Felicity Browner		
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5 Howick Place,

London, SW1P 1WG

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Table of Contents

1.	Introduction.....	1
1.1	Overview of the In-Principle Monitoring Plan (IPMP).....	1
1.2	Hornsea Three.....	1
2.	General principles and guidance	1
2.1	Guidance	1
2.2	Mitigation	1
2.3	Principles.....	2
3.	Consultation.....	2
3.1	Summary of Relevant Representations	2
4.	In Principle Proposals for Monitoring	3
4.1	Approach	3
4.2	Engineering and design related studies.....	3
4.3	Marine Processes.....	4
4.4	Benthic Ecology	6
4.5	Fish and Shellfish Ecology.....	9
4.6	Marine Mammals	9
4.7	Offshore Ornithology.....	12
4.8	Offshore Historic Environment.....	14
4.9	Commercial Fisheries.....	14
4.10	Shipping and Navigation.....	14
5.	References	16

List of Tables

Table 4.1:	Indicative engineering and design studies.....	3
Table 4.2:	In-principle monitoring – Marine Processes.....	5
Table 4.3:	In-principle monitoring – Benthic Ecology.....	7
Table 4.4:	In-principle monitoring – Marine Mammals.....	11
Table 4.5:	In-principle monitoring – Offshore Ornithology.....	13
Table 4.6:	In-principle monitoring – Shipping and Navigation.....	15

Acronyms

Acronym	Description
ADCP	Acoustic Doppler Current Profiler
ADD	Acoustic Deterrent Device
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CPT	Cone Penetration Test
DCO	Development Consent Order
dML	Deemed Marine Licence
EIA	Environmental Impact Assessment
EMF	Electro-Magnetic Field
FLOWW	The Fishing Liaison with Offshore Wind and Wet Renewables Group
HDD	Horizontal Directional Drill
IPMP	In-Principle Monitoring Plan
LiDAR	Light Detection and Ranging
MCA	Maritime and Coastguard Agency
MCZ	Marine Conservation Zone
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MMMP	Marine Mammal Mitigation Protocol
MMMZ	Marine Mammal Mitigation Zone
NNSSR	North Norfolk Sandbanks and Saturn Reef
NRA	Navigational Risk Assessment
OMP	Ornithological Monitoring Plan
ORJIP	Offshore Renewables Joint Industry Programme
OSS	Offshore Substation
RIAA	Report to Inform Appropriate Assessment
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
cSAC	Candidate Special Area of Conservation

Acronym	Description
SCI	Site of Community Importance
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
pSPA	Proposed Special Protection Area
UXO	Unexploded Ordnance
WNNC	Wash and North Norfolk Coast
WSI	Written Scheme of Investigation
WTG	Wind Turbine Generator

1. Introduction

1.1 Overview of the In-Principle Monitoring Plan (IPMP)

- 1.1.1.1 Hornsea Project Three Offshore Wind Farm (hereafter referred to as Hornsea Three) produced an ‘in principle’ monitoring plan (IPMP) (Document A8.8) in order to agree the objectives of any monitoring required by the deemed Marine Licences (dMLs) prior to the grant of consent as part of its application submission. In doing so, it was the intention that this would enable all relevant parties to have clarity on the rationale associated with relevant monitoring requirements and focus from the outset, and provide greater certainty on the limitations and deliverability of any monitoring.
- 1.1.1.2 It was stated within the IPMP that it was the intention of Hornsea Three to consult on the IPMP with the Marine Management Organisation (MMO), its scientific advisor (Cefas) and its statutory nature conservation advisor (Natural England) prior to completion of the examination phase. This draft of the IPMP (V2.0) has been prepared following receipt of the Relevant Representations from the aforementioned stakeholders.
- 1.1.1.3 The IPMP sets out the in-principle monitoring proposals for the marine environment only encompassing both generation¹ and transmission² assets. For the purposes of this IPMP, ‘offshore’ refers to the land and seabed seaward of MHWS. Any reference to the Hornsea Three intertidal area shall mean the area between mean low water springs (MLWS) and mean high water springs (MHWS). Matters relating to onshore works are captured within Volume 4, Annex 5.1: Enhancement, Mitigation and Monitoring of the Environmental Statement.
- 1.1.1.4 The primary aims of this document are to:
- Identify relevant offshore monitoring as required by the conditions of the draft dMLs;
 - Establish the objectives of such monitoring; and
 - Set out the guiding principles and framework for delivering any monitoring measures as required by the conditions contained within the draft dMLs.
- 1.1.1.5 It is intended that this document will provide the basis for further discussions with the MMO and the relevant statutory advisors to agree the exact detail (timings, methodologies, etc.) of any offshore monitoring that is required by the conditions of the dMLs. It should be noted that the final detailed plans for monitoring work will not be produced until closer to the time that the actual work will be undertaken (following final scheme design). These in turn will be agreed with the MMO (as required by the conditions of the draft dMLs) in consultation with their statutory advisors where necessary.

¹ The generating infrastructure i.e., wind turbine generators and associated foundations, array cables and if required accommodation platforms.

1.2 Hornsea Three

- 1.2.1.1 Hornsea Three is a proposed offshore wind farm located in the southern North Sea, being developed by Orsted Power UK Ltd (Ørsted) and comprising up to 300 turbines and associated offshore and onshore infrastructure. The Hornsea Three offshore cable corridor extends from the Norfolk coast, offshore in a north-easterly direction to the western and southern boundary of the Hornsea Three array area and is approximately 163 km in length.
- 1.2.1.2 The Hornsea Three array area (i.e. the area in which the turbines are located) is approximately 696 km² and is located approximately 121 km northeast of the Norfolk coast and 160 km east of the Yorkshire coast. The Hornsea Three array area lies to the east of Hornsea Project One and Hornsea Project Two.
- 1.2.1.3 A detailed description of the proposed development can be found in Volume 1, Chapter 3: Project Description of the Environmental Statement (Document A6.1.3).

2. General principles and guidance

2.1 Guidance

- 2.1.1.1 There are a number of guidance documents and reviews to draw on when considering the overarching principles in marine environmental monitoring. Of particular relevance to offshore wind farms is the recent independent review of post-consent environmental monitoring data undertaken by Fugro EMU Ltd on behalf of the MMO (MMO, 2014a) and the MMO’s subsequent recommendations (MMO, 2014b).

2.2 Mitigation

- 2.2.1.1 It is important to note that Hornsea Three has sought to avoid or reduce the potential for significant impacts as part of the iterative environmental impact assessment (EIA) process, through the commitment to mitigation measures as part of the Project design (termed “measures adopted as part of Hornsea Three”). These include mitigation measures embedded in the project design as well as additional mitigation measures to be applied during construction, operation and decommissioning of Hornsea Three; further details regarding these measures will be prepared in consultation with and for agreement from the MMO in consultation with other bodies as deemed appropriate by the MMO.
- 2.2.1.2 Options for monitoring are appropriate to consider where it has not been agreed that there are no significant residual impacts (following mitigation), or where there is significant uncertainty in the assessment conclusions relating to a particularly sensitive feature that requires validation to ensure the predictions are valid.

² The electrical transmission infrastructure, i.e., export cables, interconnector cables, substations and if required booster station.

2.3 Principles

2.3.1.1 The guiding principles which apply to the in-principle monitoring approaches outlined in this document are as follows:

- Paragraph 2.6.51 of the National Planning Statement for Renewable Energy Infrastructure (EN-3) states that “monitoring is to measure and document the effects of the development. This enables an assessment of the accuracy of the original predictions and may inform the scope of future Environmental Impact Assessments (EIAs)”;
- All consent conditions (including those for monitoring) should be “necessary, relevant to planning, relevant to the permitted development, enforceable, precise and reasonable in all other respects” (the “six tests” set out in paragraph 206 of the National Planning Policy Framework, Department for Communities and Local Government, 2012);
- Monitoring should have a clear purpose and be designed to provide answers to specific questions where significant environmental impacts have been identified (Cefas, 2012; Glasson et al., 2011; OSPAR, 2008). As such (and in-line with the MMO’s recommendations for targeted monitoring (MMO, 2014)), monitoring proposals should have an identified frequency (and/ or duration) and confirmed outputs, which provide statistically robust datasets designed to address the hypothesis being tested;
- The presence of a significant impact identified in the EIA (whilst necessitating mitigation) should not, in itself, necessarily lead to a requirement for monitoring. Monitoring should address significant evidence gaps or uncertainty relevant to Hornsea Three, where it is realistic for those gaps to be filled or uncertainty reduced significantly. Monitoring should also be targeted at those features considered to be particularly sensitive to the impacts of the development, especially where these features are of economic or environmental importance. MMO (2014) advise that the greatest focus should be placed on impacts of concern for which the highest uncertainty remains. Such targeted monitoring is more likely to answer key uncertainties than broad scale / generic monitoring approaches;
- Proposals for monitoring should be based, where relevant, on the best practice and outcomes of the latest review of environmental data (i.e., best available evidence) associated with post-consent monitoring of licence conditions of offshore wind farms (MMO, 2014);
- An iterative approach should be taken whereby the scope and design of any new monitoring work should be based on a review of the findings of any preceding phases of monitoring or relevant survey work, including surveys carried out in support of the EIA for Hornsea Three. It is acknowledged that the MMO may require amendments to individual monitoring programmes if the evidence indicates the existing monitoring programme is not fit for purpose and/or impacts are not as predicted;

- Where site specific monitoring is undertaken pre- and post-construction it may be relevant to consider undertaking monitoring over non-consecutive years (for example post construction monitoring at years one, three and five following completion, or years one, five and ten) to explore potential for longer term trends; and
- Under certain circumstances for addressing specific uncertainties it may be more appropriate to adopt a strategic approach to the monitoring (for example the bird collision assessment work that ORJIP³ is undertaking, or the consequence of harbour porpoise disturbance that DEPONS⁴ is addressing). Strategic work (potentially outwith the boundary of Hornsea Three) may be considered where contributing to the answering of a broader question (that is still linked to the relevant Project receptors) is likely to offer greater ability to address key questions than any site-specific monitoring may achieve. Such strategic work may need to be de-coupled from any specific phase of the development.

3. Consultation

3.1 Summary of Relevant Representations

3.1.1.1 Both Natural England and the MMO raised comments on the existing monitoring proposals and also the In-Principle Monitoring Plan within their Relevant Representations. A detailed response to these specific points raised can be found in Annex 6 and 7 of the Applicant’s comments to Relevant Representations submitted at Deadline I. The following provides a summary of those points raised and how the Applicant has had due regard to them within this updated IPMP:

MMO

- 1.8, 4.3, 7.2 & 7.3: Detail and nature of benthic monitoring commitment; and
- 7.1: Request for nearshore monitoring of bathymetric conditions around areas where cable protection is applied.

Natural England

- 5.8.1: Greater clarity within the IPMP is needed on the hypotheses to be answered by the monitoring;
- A5: Detail and nature of benthic monitoring commitment; and
- A.8: Level of commitment to post consent monitoring.

³ Offshore Renewables Joint Industry Programme (ORJIP). ORJIP is a UK-wide collaborative programme of environmental research with the aim of reducing consenting risks for offshore wind and marine energy projects. Currently there are two ORJIP streams: Offshore Wind and Ocean Energy

⁴ DEPONS is a collaborative project between industry and academia to enhance the knowledge of the consequence of disturbance to harbour porpoise when exposed to underwater noise.

4. In Principle Proposals for Monitoring

4.1 Approach

4.1.1.1 The following sections set out the in-principle proposals for implementing the monitoring conditions for Hornsea Three. The proposals have been grouped into the following topics:

- Marine processes;
- Benthic ecology;
- Fish and shellfish ecology;
- Marine mammals;
- Ornithology;
- Shipping and navigation; and
- Marine archaeology.

4.1.1.2 For each topic, a table is presented which details the potential effects and receptor(s) for which monitoring is considered necessary, with links to the relevant dML conditions that set out monitoring requirements and, where relevant, requirements for submission of related plans. For each topic, the tables are divided into sections for pre-construction monitoring, construction monitoring, and post-construction monitoring. At this stage, no monitoring approaches are outlined for the decommissioning phase.

4.1.1.3 This document outlines the rationale behind the proposed monitoring, with a view to reducing uncertainty when drafting the final plans post grant of a Development Consent Order (DCO). Following the iterative approach recommended in Section 2, it should be recognised that increased knowledge and understanding based on survey outcomes may influence the design of subsequent monitoring work. The focus, requirements and methodologies for future monitoring for Hornsea Three may therefore differ from the outline approach presented in this document. Any such future modifications to monitoring approaches will be the subject of ongoing consultation between the undertaker, the MMO and its statutory advisers. The MMO has the ability to vary the dML conditions in this regard, in consultation with the Applicant.

4.2 Engineering and design related studies

4.2.1.1 It is important to note that in addition to environmental monitoring programmes as required under the Conditions of the dMLs, a suite of monitoring activity will be carried out by the Applicant for engineering and design purposes (some of which may be commercially sensitive). It may transpire that some of these surveys may also be used to inform specific environmental monitoring requirements where relevant. An indicative list of the engineering and design related studies that the Applicant considers likely (at this stage) to be carried out during the construction, operation & maintenance and, decommissioning phases are set out in Table 4.1.

Table 4.1 Indicative engineering and design studies.

Purpose	Detail	Link to environmental monitoring
Pre-construction studies		
Site investigation for final scheme design and site preparation	<p>Geophysical and geotechnical surveys to inform aspects including:</p> <ul style="list-style-type: none"> • Wind Turbine Generator (WTG) and Offshore Substation (OSS) foundation design and siting; • Cable crossing design; • Horizontal Directional Drill (HDD) design and siting; • Cable design, burial and protection plans and siting; • Scour protection requirements; • Boulder clearance requirements; • Sandwave clearance requirements; and • Initial unexploded ordnance (UXO) clearance requirements. <p>Geophysical survey techniques may include use of high resolution side scan sonar, multibeam echosounder, magnetometer, sub-bottom profiler, and remotely operated vehicle (ROV).</p> <p>Geotechnical survey techniques may include use of boreholes, cone penetration tests (CPTs), vibrocores, acoustic corers and grabs.</p> <p>Survey extents will cover the areas within which construction activity is proposed plus appropriate buffers to inform any micrositing requirements.</p>	<p>Geophysical survey outputs will inform the benthic and archaeological monitoring.</p> <p>Geotechnical survey outputs will inform the archaeological monitoring.</p>
Meteorological studies	<p>Studies required to inform final scheme design and operation efficiency.</p> <p>Equipment that may be deployed includes, meteorological masts, fixed or floating LiDARs, wave buoys, acoustic doppler current profilers (ADCPs), tide gauges etc.</p> <p>Note any equipment deployed during the construction phase may be present through</p>	N/A

Purpose	Detail	Link to environmental monitoring
	the construction and part of the operation phase. This information is not repeated in the subsequent rows within this table.	
Construction studies		
Footprint surveys	<p>Studies required to ensure the safe placement of jack-up vessel legs on the seabed during construction. Techniques may include:</p> <p>Geophysical surveys using high resolution side scan sonar and multibeam echosounder and ROV techniques.</p> <p>Survey extents will cover the areas within which construction activity using jack-up vessels is proposed.</p>	May inform archaeological monitoring?
Post construction studies		
As-built surveys	<p>Geophysical surveys (techniques as described under pre-construction phase) to confirm:</p> <ul style="list-style-type: none"> • Cable burial depth; • Adequate protection of buried assets, foundations and crossings; and • Presence of any dropped objects. <p>Survey extents will cover the areas within which construction activity has taken place.</p>	Geophysical survey outputs may inform any post construction benthic and archaeological monitoring.
Operation & Maintenance phase studies		
Asset protection studies	<p>Periodic geophysical surveys to ensure that assets remain suitably buried and or protected and where necessary, inform of the need for any remedial measures (re-burial / further protection etc).</p> <p>Techniques will be as described under pre-construction phase.</p> <p>The extent of surveys will be informed by the level of risks associated with the buried and or protected assets as informed by the as-built surveys.</p>	Geophysical survey outputs may inform any post construction benthic and archaeological monitoring.
Footprint surveys	Studies required to ensure the safe placement of jack-up vessel legs on the seabed during any maintenance activity. Techniques will be as set out under the construction phase.	N/A

Purpose	Detail	Link to environmental monitoring
	Survey extents will cover the areas within which construction activity using jack-up vessels is proposed.	

4.3 Marine Processes

4.3.1.1 Changes to marine processes have the potential to indirectly impact other environmental receptors. For instance, the creation of sediment plumes (which is considered in Volume 2, Chapter 1: Marine Processes of the Environmental Statement (Document A6.2.1)) may lead to settling of material onto benthic habitats. Similarly, scour around Hornsea Three marine infrastructure may lead to a loss or modification of seabed habitat. In addition to indirect changes, the presence of Hornsea Three marine infrastructure will lead to a direct loss (or temporary/permanent change) of seabed habitat.

4.3.1.2 Whilst marine processes can largely be considered as pathways, a small number of features have been identified as potentially sensitive marine processes receptors. These are: the shoreline, offshore sandbanks and the Flamborough Front. All assessments of potential impacts to the shoreline, offshore sandbanks and the Flamborough Front result in effects of negligible or minor significance (Volume 2, Chapter 1: Marine Processes of the Environmental Statement). This is because for the most part, the magnitude and nature of any impact from Hornsea Three is not expected to be measurable against the range of natural variability.

4.3.1.3 Notwithstanding these findings from the EIA, the Applicant is cognisant of the concerns raised by the MMO and Natural England within their Relevant Representations and has therefore made a number of marine process monitoring commitments as detailed within Table 4.2.

Table 4.2: In-principle monitoring – marine processes

Potential Effect	Receptor(s)	Monitoring approach	Monitoring objectives	Links to other monitoring
Pre-construction monitoring				
Nearshore changes in bathymetric profile following application of cable protection Effects on sandwaves in designated sites Effects on seabed sediments in designated sites following application of cable protection	Seabed sediments Annex I sandwave features	A comprehensive geophysical survey (described in Table 4.1) to encompass the areas within which construction activity is planned, both within the Hornsea Three array area and along the Hornsea Three offshore cable corridor, up to MLWS. The survey will be undertaken prior to commencement of construction (and therefore, seabed preparation works) to enable a baseline to be established against which post-construction monitoring outlined below can be compared.	To establish a baseline for the post-construction marine process monitoring.	See pre-construction geophysical surveys undertaken for engineering purposes in Table 4.1.
Construction monitoring				
N/A	-	-	-	-
Post-construction monitoring				
Effects on sandwave features in designated sites	Sediments and sandwaves, comprising part of the Annex I sandbank features of SACs	Geophysical surveys (as described in Table 4.1) will be undertaken at a representative number of locations within the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC and The Wash and North Norfolk Coast (WNNC) SAC where sandwave clearance activity has taken place. The number of locations will be dependent on the amount of sandwave clearance activities undertaken within each designation and will be discussed and agreed with MMO, in consultation with Natural England prior to the undertaking of the surveys. The scope of surveys will be identical to pre-construction surveys to ensure a direct comparison between the pre-construction and post-construction outputs can be made. The first survey will be undertaken within one year following completion of cable installation works. The need for any further monitoring surveys will be discussed with the MMO. Further monitoring of the sandwave recovery will be undertaken on a timescale and frequency to be agreed with the MMO, up to a maximum of two additional surveys.	To test the prediction that sandwave features will recover to a new equilibrium following pre-lay clearance and cable installation works in designated sites.	Benthic monitoring
Effects on bathymetric profile in designated sites following application of cable protection	Bathymetric profile and seabed sediments within designated sites	Geophysical surveys (as described in Table 4.1) will be undertaken within the NNSSR SAC, the WNNC SAC and the Cromer Shoal Chalk Beds MCZ in the areas immediately surrounding cable protection placement. The scope of surveys used will be like for like with the pre-construction surveys to ensure a direct comparison between the pre-construction and post-construction outputs can be made. The first survey will be undertaken within one year following completion of installation of cable protection. The need for any further monitoring surveys will be discussed with the MMO. Where further surveys are required (up to a maximum of two), these should be undertaken within a sufficient timeframe to allow for a morphological response to have occurred.	To test the prediction that there will be no significant effects on sediment transport processes in the vicinity of cable protection material following installation of cable protection measures within designated sites.	Benthic monitoring

4.4 Benthic Ecology

- 4.4.1.1 Table 4.3 provides information on the in-principle monitoring for benthic ecology during the pre-construction, construction- and post-construction phases.
- 4.4.1.2 It is anticipated that methodologies for benthic ecology survey and monitoring will be required to follow the guidelines set out in Cefas (2012) and Ware and Kenny (2011), being cognisant of the outcomes of the post-consent monitoring review (MMO, 2014a and b). It is considered likely that the approach to monitoring will comprise a combination of techniques including interpreted information from the geophysical surveys undertaken for engineering purposes (see Table 4.1) and ground-truthing in the form of remote and or intrusive sampling.
- 4.4.1.3 A number of potential impacts on benthic ecology, associated with the construction, operation and maintenance, and decommissioning of Hornsea Three have been identified. These are related to temporary habitat loss/disturbance from construction activity and installation of infrastructure and long-term habitat loss of seabed habitat through the presence of foundations and scour protection. Temporary and long-term habitat loss/disturbance was deemed to be of minor adverse significance to benthic receptors in the Hornsea Three benthic ecology study area, with the proportion of habitat lost predicted to be small in the context of available habitats in the southern North Sea benthic ecology study area.
- 4.4.1.4 Whilst the impact assessment did not identify any significant adverse effects, it is recognised that certain activities within key designated sites have been raised as points of concern by stakeholders through the Evidence Plan process and within Relevant Representations. In addition to this it is also recognised that there is a commitment (as an embedded measure) to avoid where possible, priority habitats (such as biogenic and or geogenic reef). Therefore, the monitoring proposed is reflective of the concerns and commitment made.

Table 4.3: In-principle monitoring – benthic ecology

Potential Effect	Receptor(s)	Monitoring approach	Monitoring objectives	Links to other monitoring
Pre-construction monitoring				
Direct impacts from construction activity on reef features	Reefs (i.e. biogenic and/or geogenic reef)	<p>The benthic pre-construction monitoring for reefs will be primarily delivered through the geophysical surveys described in Table 4.1 and Table 4.2.</p> <p>The coverage will comprise all areas within which construction activity is proposed within the Hornsea Three array area, offshore cable corridor and adjacent temporary working area (to cover direct effects) plus an appropriate buffer (to be agreed with the MMO).</p> <p>In the first instance, the pre-construction geophysical survey outputs will be interpreted to identify any areas of potential reef features. Any acoustic signatures synonymous with reef presence will be subject to further ground-truthing through remote sampling techniques (e.g. drop down video) to establish the presence or absence of any reef features, and where present to determine their extent. This approach is consistent with the relevant guidance documents (e.g. Limpenny <i>et al.</i>, 2010).</p>	<p>To identify (and confirm location, extent and composition of) any reef features that may develop within the areas within which construction activity is planned plus an appropriate buffer (to be agreed with the MMO).</p> <p>The monitoring will directly inform discussions with the statutory consultees to determine appropriate mitigation measures to avoid direct impacts to Annex I reef features, where possible. The mitigation measures will be detailed within the Cable Specification and Installation Plan.</p> <p>The monitoring may also inform the requirement for further post-construction monitoring (of any features identified within proximity to areas within which construction activity is planned).</p>	See pre-construction geophysical surveys undertaken for engineering and marine process purposes in Table 4.1 and Table 4.2.
Direct impacts from cable installation (including HDD operations) on seabed sediments	Seabed sediments including sub-features of Annex I habitat <i>Sandbanks which are slightly covered by sea water all of the time</i> and designated ecological features of the Cromer Shoal Chalk Beds MCZ	<p>A comprehensive geophysical survey (described in Table 4.1 and Table 4.2) to encompass the areas within which construction activity is planned, both within the Hornsea Three array area and along the Hornsea Three offshore cable corridor, up to MLWS.</p> <p>The survey will be undertaken prior to commencement of construction (and therefore, seabed preparation works) to enable a baseline to be established against which post-construction monitoring outlined below can be compared.</p>	To provide a baseline against which predictions relating to recovery of the seabed following cable installation, with specific reference to the Annex I sandbank features within NNSSR SAC and the WNNC SAC (and relevant sub-features).	See pre-construction geophysical surveys undertaken for engineering and marine process purposes in Table 4.1 and Table 4.2.
Construction monitoring				
N/A	-	-	-	-
Post-construction monitoring				
Direct effects from construction activity on reef features	Reefs (i.e. biogenic and/or geogenic reefs)	<p>Benthic post-construction monitoring for reefs will be primarily delivered through the geophysical surveys described in Table 4.1 and Table 4.2.</p> <p>The coverage of the monitoring will comprise any areas confirmed during the pre-construction surveys as reef habitat (biogenic or geogenic) within which construction activity occurs within the Hornsea Three array area and offshore cable corridor (to cover direct effects) plus an appropriate buffer (to be agreed with the MMO).</p> <p>In the first instance, the post-construction geophysical survey outputs will be interpreted to identify any areas of potential reef habitat. Any acoustic signatures synonymous with reef presence will be subject to further ground-truthing through remote sampling techniques (e.g. drop down video) to establish whether the location, nature and/or extent of reef features has changed following construction.</p>	To determine any change in the location, extent and/or composition of reef habitats within the areas within which construction activity is planned plus an appropriate buffer (to be agreed with the MMO).	See post-construction geophysical surveys undertaken for engineering and marine process purposes in Table 4.1 and Table 4.2

Potential Effect	Receptor(s)	Monitoring approach	Monitoring objectives	Links to other monitoring
Effects on seabed sediments and benthic habitats as a result of cable installation and Horizontal Directional Drilling (HDD)	Seabed sediments including sub-features of Annex I habitat <i>Sandbanks which are slightly covered by sea water all of the time</i> and designated ecological features of the Cromer Shoal Chalk Beds MCZ	Benthic post-construction monitoring of the impacts associated with cable installation (including HDD exit pits) will be delivered through the geophysical surveys described in Table 4.1 and Table 4.2. Post construction geophysical surveys (as described in Table 4.1) will be undertaken at a representative number of locations within the NNSSR SAC and the WNNC SAC Cromer Shoal Chalk Beds MCZ where cable installation (including excavation of HDD exit pits) has taken place. The need for any further monitoring surveys will be discussed with the MMO and determined on the basis of the level of recovery of sediments in the locations sampled, up to a maximum of two additional surveys. The purpose being to establish any changes in the topographic complexity of seabed features and or sediment composition as a result of the cable burial and excavation of HDD exits pits. The surveying and analysis techniques used will be like for like with the pre-construction surveys to ensure a direct comparison between the pre-construction and post-construction outputs can be made.	To validate predictions regarding the recovery of the seabed sediments (and therefore associated benthic communities) associated with cable installation.	See post-construction geophysical surveys undertaken for engineering and marine process purposes in Table 4.1 and Table 4.2
Long term loss of seabed habitat within designated sites through presence of cable and scour protection	Designated ecological features of the North Norfolk Sandbanks and Saturn Reef SAC, The Wash and North Norfolk coast SAC and Cromer Shoal Chalk Beds MCZ	<p>Survey(s) to monitor a representative proportion of the Hornsea Three offshore cable corridor within designated sites (i.e. North Norfolk Sandbanks and Saturn Reef SAC, The Wash and North Norfolk coast SAC and Cromer Shoal Chalk Beds MCZ) in areas where sensitive cable protection material is deployed. These will primarily comprise of seabed imagery surveys (e.g. Remote Operated Vehicle; ROV) to determine the level of colonisation of cable protection and/or accumulation of sediments on cable protection measures.</p> <p>The number of sampling locations is to be confirmed post consent and will be informed by the number of locations where cable protection is deployed within each designated site. The aim of the surveys will be to determine the success of sensitive cable protection measures within designated sites by monitoring the behaviour/recovery of the sediments associated with the cable protection over an agreed period of time and by monitoring any recolonisation/recovery of the associated benthic communities. The need for any further monitoring surveys will be discussed with the MMO and determined on the basis of the level of colonisation of cable protection and or accumulation of sediments on cable protection, up to a maximum of two additional surveys. Full details of the surveys will be agreed with the MMO in consultation with the statutory consultees.</p> <p>The results of post construction marine processes monitoring of cable protection (i.e. geophysical survey; see Table 4.2) would also be used to inform this monitoring, i.e. aiding to determine the level of sediment accumulation on cable protection measures.</p>	To monitor the effectiveness of sensitive cable protection within designated sites.	See post-construction geophysical surveys undertaken for engineering and marine process purposes in Table 4.1 and Table 4.2

4.5 Fish and Shellfish Ecology

- 4.5.1.1 Characterisation of the baseline environment through both survey data from the former Hornsea Zone⁵ and a desk-based literature review found the species assemblage of the Hornsea Three fish and shellfish study area to be typical for this region of the southern North Sea fish and shellfish study area (Section 3.3 of Volume 2, Chapter 3: Fish and Shellfish Ecology of the Environmental Statement (Document A6.2.3)).
- 4.5.1.2 The impacts on fish and shellfish receptors from all stages of Hornsea Three were assessed, including impacts from habitat loss, underwater noise, increased SSC and deposition, sediment contaminants and pollution events, and electro-magnetic fields (EMF). Throughout the construction, operation and decommissioning phases, all impacts were found to have either negligible, minor adverse or minor beneficial effects on fish or shellfish receptors within the Hornsea Three fish and shellfish study area (i.e. not significant in EIA terms). Underwater noise from construction activities such as pile driving was not predicted to overlap with key fish spawning habitats within the southern North Sea fish and shellfish study area. No barrier effects were predicted on migratory fish species listed as features of SACs/SCIs in the southern North Sea fish and shellfish study area, including the Humber Estuary SAC (Section 3.11 of Volume 2, Chapter 3: Fish and Shellfish Ecology of the Environmental Statement).
- 4.5.1.3 Herring are known to have important spawning habitats in the southern North Sea, though the highest intensity spawning grounds for this species are located to the west of the former Hornsea Zone, off Flamborough Head, approximately 80 km to the west of the Hornsea Three array area. The Hornsea Three array area is noted as being “low intensity” for sandeel spawning.
- 4.5.1.4 Given the lack of potential for significant effects or overlap with key active demersal spawning grounds, and in keeping with the guiding principles of monitoring as set out in Section 2 of this document, no site specific monitoring of fish resource is proposed.

4.6 Marine Mammals

- 4.6.1.1 Underwater noise from foundation piling within the Hornsea Three array area has the potential to cause injury or disturbance to marine mammals. Marine mammals use sound for foraging, orientation, communication, navigation, echolocation of prey and predator avoidance, and are therefore potentially susceptible to elevated levels of anthropogenic sound that may impair auditory cues or disrupt normal behaviour (Richardson *et al.*, 1995). The key marine mammal species across the Hornsea Three Order limits are considered to be harbour porpoise, white-beaked dolphin, minke whale, grey seal and harbour seal. Appropriate embedded measures have been committed to as part of the project design to prevent significant impact for injurious and lethal effects (through the Marine Mammal Mitigation Protocol (MMMP)). Key components of the impact assessment for underwater noise effects on marine mammals are considered to be:

- The conclusion of a potential short term moderate impact on harbour porpoise as a result of cumulative piling activity; with the key uncertainty associated with this prediction relating to the consequence of disturbance; and
- The assumptions made in relation to the duration of piling activity under the realistic maximum design scenario. These assumptions directly influence the level of exposure to underwater noise that marine mammal receptors are assumed to receive, and therefore, they have a material bearing on the conclusions drawn within the assessment.

- 4.6.1.2 As identified above, a MMMP will be submitted to the MMO for approval in advance of works commencing and the approved MMMP will be implemented during construction. The MMMP will detail mitigation measures which may include soft-start to piling, identification of a Marine Mammal Mitigation Zone (MMMZ) and/or detailed methods to be employed within the MMMZ. The MMMP will set out the mitigation necessary to ensure that the potential for lethal and or injurious effects are appropriately mitigated prior to the commencement of piling. This may include forms of monitoring such as the use of visual or passive acoustic techniques. Any such monitoring carried out under the MMMP is not formal monitoring in the context of addressing key uncertainties and or validating key impact predictions, but rather it is monitoring as part of a mitigation package. Nonetheless it has been included within this IPMP document for completeness.

4.6.1.3

⁵ The Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by The Crown Estate (TCE) during its third round of offshore wind licensing. In March 2016, the Hornsea Zone Development Agreement was terminated and project specific

agreements, Agreement for Leases (Afls), were agreed with The Crown Estate for Hornsea Project One, Hornsea Project Two, Hornsea Three and Hornsea Project Four. The Hornsea Zone has therefore been dissolved and is now referred to as the former Hornsea Zone.

4.6.1.4 Table 4.4 provides information on the in-principle monitoring for marine mammals during the pre-construction, construction and post-construction phases, noting that the precise form of any future monitoring for marine mammals will be set out within a Plan for Marine Mammal Monitoring⁶, which will be approved by the MMO prior to the commencement of offshore works. Table 4.4 provides information on the in-principle monitoring for marine mammals during the pre-construction, construction and post-construction phases, noting that the precise form of any future monitoring for marine mammals will be set out within a Plan for Marine Mammal Monitoring, which will be approved by the MMO prior to the commencement of offshore works. It is important to note that the monitoring is set out in a pre-, during and post construction format within this document to align with the manner in which conditions are captured within the dMLs only. It is not necessarily the case that monitoring will take place in such a structured format. For example, if it is determined during the development of the Plan for Marine Mammal Monitoring that contribution to a strategic study forms the most appropriate means of monitoring then the timing of this contribution may not directly link to a particular phase of the development.

⁶ Note the Plan for Marine Mammal Monitoring is not to be confused with the MMMP which is the protocol for mitigation applied to ensure significant adverse effects will not occur to marine mammals.

Table 4.4: In-principle monitoring – marine mammals

Potential Effect	Receptor(s)	Monitoring approach	Monitoring objectives	Links to other monitoring
Pre-construction monitoring				
Behavioural disturbance from foundation installation (i.e., percussive piling)	Marine mammals	Monitoring as required under the Plan for Marine Mammal Monitoring. The key uncertainty relates to the population level consequence of disturbance when considering cumulative level disturbance. It is well established that addressing such a high level uncertainty is best achieved through industry wide studies / initiatives that have the ability to tackle these population level cumulative concerns. It is therefore, likely that a commitment to contribute to any such industry wide studies would be the most pragmatic approach to monitoring for this topic. However, whilst it is recognised that monitoring at the individual project level is too small scale to address such population scale cumulative level uncertainty, consideration will be given to site-specific monitoring based on where it is established that there is a specific information gap within a wider strategic study that could be meaningfully filled at the individual project level.	Specific objectives of any such monitoring would be to help reduce the uncertainty relating to the consequence of disturbance from piled foundation installation, particularly at a cumulative level.	-
Construction monitoring				
Lethal and injurious effects as a result of foundation installation (i.e., percussive piling)	Marine mammals	Marine mammal monitoring to inform mitigation as required under the MMMP. If monitoring forms part of the MMMP then it may comprise either (or a combination of) visual observation or acoustic monitoring. Note that if alternative options are adopted (such as through the use of ADDs) then this monitoring may not be required.	In the circumstance that visual and or acoustic methods are used, the objectives will be to survey for the presence of marine mammals to ensure they are not within the relevant impact zone prior to the onset of piling and inform the implementation of appropriate mitigation actions.	-
Effects as a result of foundation installation (i.e., percussive piling)	Marine mammals	Monitoring to validate the underwater noise modelling that underpins the impact assessment. Monitoring will only be undertaken if it is not possible to demonstrate that the existing evidence base does not provide appropriate validation at the time of drafting the plan. Unless the MMO agrees otherwise in writing, measurements of noise generated by the installation of the first four foundations of each discrete foundation type to be constructed under this licence where driven or part-driven pile foundations are used. The transects monitored in the survey will be informed by the predictions for noise propagation within the Environmental Statement.	To validate the noise propagation and source level attenuation predictions made in the ES.	-
		Monitoring the actual duration of piling activity during the installation of the turbine and substation foundations. The monitoring outputs will be provided to the MMO following the completion of the construction phase.	To increase the level of certainty in the piling duration assumptions within impact assessments given the material influence such assumptions have on the level of effect associated with underwater noise impacts on marine mammals.	-
Post-construction monitoring				
Behavioural disturbance from foundation installation (i.e., percussive piling)	Marine mammals	Monitoring as required under the Plan for Marine Mammal Monitoring. see Construction phase	See Construction phase	-

4.7 Offshore Ornithology

- 4.7.1.1 Table 4.5 provides information on the in-principle monitoring for offshore ornithology during the pre- and post-construction phases.
- 4.7.1.2 A number of potential impacts on offshore ornithology, associated with the construction, operation and decommissioning of Hornsea Three, have been identified (Volume 2, Chapter 5: Offshore Ornithology of the Environmental Statement (Document A6.2.5)). The impacts identified for Hornsea Three alone are predicted to have no more than a minor adverse effect on all receptors at a regional or national level. Moderate adverse effects are predicted at a cumulative level for displacement and collision risk impacts on a number of receptors including guillemot, gannet, lesser-black backed gull and great black-backed gull.
- 4.7.1.3 Areas of uncertainty identified within the assessments relate to flight heights, demographics and proportion of SPA breeding birds at the Hornsea Three array area, foraging ranges, avoidance rates and the consequence of displacement.
- 4.7.1.4 A site specific Ornithological Monitoring Plan (OMP) is to be developed, as described in Table 4.5 with the aim of addressing key uncertainties where practicable.
- 4.7.1.5 It should be noted that whilst monitoring is set out in a pre-, during and post-construction monitoring format within this table, flexibility may be sought to ensure that the monitoring taken forward is done in the most appropriate way. It therefore, may be de-coupled from the standard pre-, during and post construction approach (and potentially be linked to wider strategic monitoring initiatives) if it is deemed (and agreed with the MMO) that a more appropriate monitoring schedule is merited.

Table 4.5 In-principle monitoring – offshore ornithology

Potential Effect	Receptor(s)	Monitoring approach	Monitoring objectives	Links to other monitoring
Pre-construction monitoring				
<p>The impact of displacement from an area around turbines and other ancillary structures during the operational phase of the development may result in effective habitat loss and reduction in survival or fitness rates.</p> <p>The impact of collisions with rotating turbine blades may result in direct mortality of individuals.</p>	<p>Key bird species including kittiwake, gannet, razorbill, guillemot and puffin.</p> <p>The principle SPA feature of concern (linked to the key species) is the Flamborough and Filey Coast pSPA.</p>	<p>An Ornithological Monitoring Plan (OMP) will be developed. The options that are likely to be considered during the drafting of the OMP (post consent) will include site specific studies (including standardised pre-and post-construction surveys), colony specific studies and or contributions to more industry wide strategic work. Furthermore, the approach to the Hornsea Three OMP will be cognisant of Hornsea Project One and Hornsea Project Two monitoring and wider strategic work from the Applicant and ensure that any monitoring is complementary to or repetitive of this.</p> <p>The form and nature of the monitoring that is recommended within the OMP will be based on the final form of the consent, the final project design, the current industry knowledge/knowledge gaps relevant to those effects predicted for Hornsea Three (and the key receptors / risks as identified from a desk based review) at the time of drafting the OMP. The OMP will be approved by the MMO in consultation with Natural England.</p> <p>Strategic work may represent options such as a contribution to an industry wide study (i.e., via ORJIP), or a contribution towards (for example) colony specific work being carried out by another party (i.e., not directly related to Hornsea Three) the results of which will enhance the knowledge base for future development etc.</p> <p>Any site-specific monitoring will focus on key species and seasons identified from a desk based review of the Environmental Statement and RIAA.</p>	<p>To establish a baseline to test key predictions or address specific areas of uncertainty relating to key receptors as identified in the Environmental Statement and RIAA (and summarised within this IPMP).</p>	-
Construction monitoring				
N/A	-	-	-	-
Post-construction monitoring				
<p>Direct disturbance to birds including displacement from important foraging and habitat</p>	<p>Key bird species including kittiwake, gannet, razorbill, guillemot and puffin.</p> <p>The principle SPA feature of concern (linked to the key species) is the Flamborough and Filey Coast pSPA.</p>	<p>As per pre-construction.</p>	<p>To establish any significant change from baseline conditions to test key predictions or address specific areas of uncertainty relating to key receptors in the Environmental Statement and RIAA.</p>	-

4.8 Offshore Historic Environment

4.8.1.1 The need for and scope of monitoring associated with the historic environment will be set out within the Written Scheme of Investigation (WSI). An Outline WSI has been submitted as part of the application for Development Consent (A6.5.9.2). This document will be monitored and updated throughout the post-consent process (in consultation with Historic England) to ensure that the scheme of investigation is appropriate to the final project design and incorporates the results of pre-construction monitoring surveys (such as the high resolution swath bathymetric pre-construction surveys). Prior to construction commencing, the Outline WSI will be finalised and submitted to the MMO for approval, noting that this document will then remain live and be updated by the undertaker (in consultation with the MMO) based on outputs from any relevant site investigation works undertaken throughout the construction, operation and decommissioning phases as appropriate.

4.9 Commercial Fisheries

4.9.1.1 Potential impacts on commercial fisheries interests through the construction, operation and maintenance, and decommissioning of Hornsea Three are, for the majority of the effects identified, not predicted to be significant in EIA terms, with the exception to this being disruption to the local UK potting fleet during the construction and decommissioning phases. Mitigation applied comprises a commitment to disturbance payments (where justifiable) following the procedures as outlined in the FLOWW guidance (2014 and 2015) wherever possible, and the development of a Fisheries Coexistence and Liaison Plan (Document A8.10.) with such measures predicted to reduce the impact to an effect of minor significance (see Volume 2, Chapter 6, Commercial Fisheries of the Environmental Statement (Document A6.2.6)).

4.9.1.2 Given the lack of significant effects on commercial fisheries receptors no impact driven monitoring is identified within the assessment (see Table 6.17, Volume 2, Chapter 6, Commercial Fisheries of the Environmental Statement). Notwithstanding this, it is noted that a post construction survey will be undertaken to identify and, where necessary, remove any construction related debris materials that may present a risk to fishing activity (see Table 6.13, Volume 2, Chapter 6, Commercial Fisheries of the Environmental Statement)The surveys that will inform this will comprise those post construction geophysical engineering surveys identified in Table 4.1 of this IPMP.

4.10 Shipping and Navigation

4.10.1.1 Table 4.6 provides information on the in-principle monitoring for shipping and navigation during the pre-construction, construction and post-construction phases.

4.10.1.2 A number of potential impacts on shipping and navigation have been identified as associated with the construction, operation and maintenance, and decommissioning of Hornsea Three (Volume 2, Chapter 7, Shipping and Navigation of the Environmental Statement (Document A6.2.7)). As described within the Environmental Statement all impacts identified can be reduced to as low as reasonably practicable (ALARP) with the implementation of the additional mitigation measures and proposed monitoring, as described in Table 4.6.

Table 4.6: In-principle monitoring – shipping and navigation

Potential Effect	Receptor(s)	Monitoring approach	Monitoring objectives	Links to other monitoring
Pre-construction monitoring				
Navigational risk	All marine traffic	High resolution bathymetric surveys as identified in Table 4.1.	To provide a baseline on bathymetry of areas within which construction activity will take place. Results from the survey will be used to inform the cable specification and installation plan, which will in turn give due consideration to the identification of any cable protection which exceeds 5% of navigable depth referenced to Chart Datum and, in the event that any area of cable protection exceeding 5% of navigable depth is identified, details of any steps (to be determined following consultation with the Maritime and Coastguard Agency) to be taken to ensure existing and future safe navigation is not compromised.	See pre-construction geophysical surveys undertaken for engineering purposes in Table 4.1.
Construction monitoring				
Displacement caused by physical presence of infrastructure	All marine traffic	Vessel traffic monitoring by Automatic Identification System (AIS) for the duration of the construction period. A report will be submitted to the MMO and the MCA at the end of each year of the construction period.	To monitor any changes in vessel routes and validate associated predictions (including use of mitigations) in the Navigational Risk Assessment (NRA) and Volume 2, Chapter 7, Shipping and Navigation of the Environmental Statement the Environmental Statement.	-
Post-construction monitoring				
Navigational risk	All marine traffic	High resolution bathymetric surveys as identified in Table 4.1.	Post construction geophysical surveys (see Table 4.1) will be used to ensure cables or indeed other exposed subsea elements are not left exposed and/or unmarked in order to, amongst other things; reduce snagging risk to anchors and fishing gear.	See pre-construction geophysical surveys undertaken for engineering purposes in Table 4.1.
Displacement caused by physical presence of infrastructure	All marine traffic	Vessel traffic monitoring by Automatic Identification system with a for 28 days taking account seasonal variations in traffic patterns for a maximum duration of one year post construction. A report will be submitted to the MMO and the MCA at the end of the first year after construction is completed.	To monitor any changes in vessel routes and validate associated predictions (including use of mitigations) in the NRA and the Volume 2, Chapter 7, Shipping and Navigation of the Environmental Statement the Environmental Statement	-

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