Hornsea Project Four

F2.7: Outline Marine Monitoring Plan (tracked)

Deadline: 7, Date: 10 August 2022
Document Reference: F2.7
Revision: 02

Prepared GoBe Consultants Ltd. August 2022
Checked GoBe Consultants Ltd. August 2022
Accepted David King, Orsted. August 2022
Approved Julian Carolan, Orsted. August 2022

F2.7
Version B

Revision Summary				
Rev	*Date*	*Prepared by*	*Checked by*	*Approved by*
01	29/09/2021	GoBe Consultants Ltd.	David King, Orsted	Julian Carolan, Orsted
02	10/08/2022	GoBe Consultants Ltd.	David King, Orsted	Julian Carolan, Orsted

Revision Change Log			
Rev	*Page*	*Section*	*Description*
01	N/A	N/A	Document submitted at application.
02	Throughout Section 3.3	3.3	Monitoring proposals related to Smithic Bank, Flamborough Front and drilling mounds added.
02	Throughout Section 3.4	3.4	Monitoring proposals related to potential sediment resampling, drill mounds, benthic communities and marine non-native invasive species added.

Table of Contents

List of Tables

Glossary

Term	Definition
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement (ES).
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Mean High Water Spring (MHWS)	The height of MHWS is the average throughout the year (when the average maximum declination of the moon is 23.5°) of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR), or ES).
National Policy Statement (NPS)	A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).

Acronyms

Acronym	Definition
ADCP	Acoustic Doppler Current Profiler
AEoI	Adverse Effect on Integrity
AfL	Agreement for Lease
AIS	Automatic Identification System
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CfD	Contracts for Difference
CPT	Cone Penetration Test
DCO	Development Consent Order
DDV	Drop Down Video
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
DML	Deemed Marine Licence
EIA	Environmental Impact Assessment
ES	Environmental Statement
FID	Final Investment Decision
HDD	Horizontal Directional Drilling
LSE	Likely Significant Effects
MBES	Multibeam Echosounder

Acronym	Definition
MCA	Maritime and Coastguard Agency
MGN	Marine Guidance Note
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
NPS	National Policy Statement
NRA	Navigational Risk Assessment
OMMP	Outline Monitoring Plan
OOMP	Outline Ornithological Monitoring Plan
OSS	Offshore Substation
PAD	Protocol for Archaeological Discoveries
PEIR	Preliminary Environmental Information Report
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SBP	Sub-Bottom Profiler
SIP	Site Integrity Plan
SPA	Special Protection Area
SSS	Side Scan Sonar
UXO	Unexploded Ordnance
WSI	Witten Scheme of Investigation
WTG	Wind Turbine Generator

Units

Unit	Definition
km	Kilometre

1 Introduction

1.1 Overview of the Outline Marine Monitoring Plan (OMMP)

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four') which will be located approximately 69 km from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (see **Volume A1, Chapter 4: Project Description** for full details on the Project Design).

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 Hornsea Four has produced this Outline Marine Monitoring Plan (OMMP) in order to outline the proposed approach and objectives of any monitoring required by conditions of the Deemed Marine Licences (DMLs) prior to the granting of development consent. In doing so, it is the intention that this will 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. It is important to note that this OMMP relates to EIA-related monitoring only. Any monitoring related to the potential compensation associated with a Regulation 64 derogation under the provisions of the Habitats Regulations will be considered separately.

1.1.1.5 It is the intention of the Applicant to consult on this OMMP with the Marine Management Organisation (MMO) and its scientific advisors (the Centre for Environment, Fisheries and Aquaculture Science (Cefas)), and its statutory nature conservation advisor (Natural England) prior to the completion of the examination phase of the DCO application. This document therefore represents an outline plan intended to form the basis of discussion during the pre-and post-application phases and the examination phase of the DCO application.

1.1.1.6 The OMMP sets out the outline monitoring proposals for the offshore environment only, encompassing the DMLs for both the generation assets, which is contained in Schedule 11 of **C1.1 Draft Development Consent Order**, and transmission assets, which is contained in

Schedule 12 of **C1.1 Draft DCO**). For the purposes of this OMMP, 'offshore' refers to areas seaward of Mean High-Water Springs (MHWS).

1.1.1.7 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, noting the limitations and deliverability of any monitoring; and
- Set out the guiding principles and framework for delivering any monitoring measures as secured by the conditions within the draft DMLs.

1.1.1.8 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 during the post-consent phase. It should be noted that the final detailed plans for monitoring work will not be produced until closer to the time that the actual works will be undertaken (following detailed scheme design). These final monitoring plans, in turn, will subsequently be provided for approval by the MMO (as required by the conditions of the draft DMLs), in consultation where necessary with their statutory advisors, in order to discharge the conditions of the corresponding final DML.

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 overarching principles in marine environmental monitoring. Of particular relevance to offshore wind farms is the 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) – see **Section 2.3** for further detail on the recommendations.

2.1.1.2 The MMO (2014b) note that the purpose of monitoring requirements that are incorporated into licence conditions are to:

a) Validate, or reduce uncertainty in predictions on environmental impacts recorded in supporting EIAs;

b) Provide evidence on the effectiveness of mitigation measures; and

c) Allow identification of any unforeseen impacts.

2.2 Commitments and Mitigation

2.2.1.1 Hornsea Four has adopted commitments (primary design principles inherent as part of Hornsea Four, installation techniques and engineering designs/modifications) as part of the pre-application phase, to eliminate and/or reduce the Likely Significant Effects (LSEs) arising from a number of potential impacts. Further commitments (adoption of best practice guidance), referred to as tertiary commitments are embedded as an inherent aspect of the EIA process. Secondary commitments are incorporated to reduce LSE, to environmentally acceptable levels following initial assessment i.e. so that residual effects are reduced, so far as possible, to environmentally acceptable levels. These commitments are outlined in **Volume A4, Annex 5.2 Commitments Register**.

2.2.1.2 Options for monitoring are appropriate to consider where significant residual effects (following mitigation) have been identified through the EIA process, or where there is a significant degree of uncertainty in the assessment conclusions relating to a particularly sensitive feature.

2.3 Principles

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

- All consent conditions (including those for monitoring) should be "necessary, relevant to planning and to the development to be permitted, enforceable, precise and reasonable in all other respects" (set out in paragraph 56 of the National Planning Policy Framework, Ministry of Housing, Communities and Local Government 2021;
- 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 2014b)), 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 effect 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 Four, 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 (2014b) 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 2014b);
- 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 Four. 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 the 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 strategic programme of tracking of kittiwake and gannet at the Flamborough and Filey Coast Special Protection Area (SPA) through the Flamborough and Filey Coast Seabird Monitoring Group, or the consequence of harbour porpoise disturbance that Disturbance Effects on the Harbour Porpoise Population in the North Sea (DEPONS[1]) is addressing). Strategic work (potentially outside the boundary of Hornsea Four) may be considered where contributing to the

[1] 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.

answering of a broader question (that is still linked to the relevant Hornsea Four receptors) is likely to offer a 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 (i.e. not specifically related to a comparison between pre-construction and post-construction data).

2.4 Consultation

2.4.1.1 Consultation with statutory consultees, including Natural England and the MMO, is fundamental to agreeing that the monitoring adopted for Hornsea Four is proportionate, effective and secured. As previously described, this document is intended to form a framework for engagement going forward following the submission of the Hornsea Four DCO Application and during the Examination phase.

2.4.1.2 The exact dates for agreement and refinement of the OMMP cannot be determined at this stage since this relies on detailed consent, procurement and construction timescales; however, key milestones have been outlined in **Table 1** to signpost the likely development of the OMMP from the point of the DCO Application through to the start of offshore construction.

Table 1: Anticipated review and revision process for the OMMP.

Development Stage	Indicative Date(s)	Applicant Actions	Relevant Statutory Authority/Advisor(s)
Pre-application review of the OMMP by the MMO and Natural England	January 2021	Provide consultees with OMMP prior to DCO Application submission. A follow up meeting was held to discuss comments in August 2021.	MMO and its scientific advisors (Cefas), in consultation with Natural England and The Wildlife Trusts.
Post-application review of the OMMP through Relevant Representations and DCO Examination	Q4 2021 – Q4 2022	Review OMMP and identify (where necessary) any areas for revisions/updates.	The Examining Authority. Consultation with Natural England, MMO and its scientific advisors (Cefas), and any other relevant interested parties.
Consent decision and Appropriate Assessment	Q1-Q2 2023	Review final DCO requirements relating to monitoring.	N/A
Design optimisation	Pre-construction	Review the Outline OMMP and agreed monitoring approaches in light of the refined project design information and scheduling, taking into account any refinements that may be required as a result of the confirmation of design details.	N/A
First draft of the final monitoring plan (or plans)	Following Contracts for Difference (CfD) award/Final Investment Decision (FID)	Based on the final design optimisation, the Applicant will draft the final monitoring plan (or plans) and submit to the MMO for approval.	MMO and its scientific advisors (Cefas), in consultation with Natural England.

Development Stage	Indicative Date(s)	Applicant Actions	Relevant Statutory Authority/Advisor(s)
Finalisation and sign-off of the final monitoring plan (or plans)	Prior to commencement of the relevant licensed activities	Update monitoring detail having regard to consultee comments.	MMO to approve the final monitoring plan (or plans).

3 Outline Proposals for Monitoring

3.1 Approach

3.1.1.1 The following sections set out the outline monitoring proposals for implementing the DML conditions related to monitoring for Hornsea Four, grouped by topic. For each topic where monitoring is proposed, a table is presented which details the potential effects (alongside the Impact ID that is used in **Volume A4, Annex 5.1: Impacts Register** and within each topic-specific ES chapter) and relevant receptor(s) for which monitoring is considered necessary. Links are also provided to the relevant DML conditions that set out monitoring requirements (**C1.1 Draft DCO including Draft DML**) and, where relevant, requirements for submission of related plans.

3.1.1.2 A draft version of this document was submitted to consultees prior to DCO Application submission, with comments received from consultees and updates made to the OMMP based on the feedback received.

3.1.1.3 This document outlines the rationale behind the proposed monitoring, with a view to providing a common understanding of the aims, objectives and approaches to guide the drafting of the final detailed monitoring plans for approval by the MMO in the post-consent phase.

3.1.1.4 Following an iterative approach, it should be recognised that increased knowledge and understanding based on survey outcomes, but also the final detailed design of Hornsea Four, may influence the detailed design of the subsequent monitoring work. The detailed focus, requirements and methodologies for future monitoring for Hornsea Four may therefore differ, to some extent, from the outline approach presented in this document. Any such future modifications to monitoring approaches will be the subject of consultation between the Applicant, the MMO and Cefas. The MMO has the ability to vary the DML conditions in this regard, in consultation with the Applicant.

3.2 Engineering and Design Related Studies

3.2.1.1 In addition to the environmental survey and monitoring programmes required by the conditions set out in **C1.1 Draft DCO**, additional studies will be undertaken for engineering and design purposes. Some of these surveys, whilst not requirements of the DMLs, can inform specific environmental monitoring requirements where relevant. An indicative list of the engineering and design related studies considered likely to be carried out, and relevant to environmental monitoring requirements, are set out in **Table 2**.

Table 2: Indicative engineering and design studies.

Study and purpose	Description	Link to environmental monitoring
Pre-construction studies		
Site investigation for final scheme design and site preparation	Geophysical and geotechnical surveys to inform aspects including: • 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. Details of the final project design will be provided within the relevant pre-construction plans, including the Scour Protection Management Plan (draft DCO Schedule 11, Part 2 – Condition 13(1)(e) and Schedule 12, Part 2 – Condition 13 (1)(e)) and the Offshore Cable Installation Plan (draft DCO Schedule 11, Part 2 – Condition 13(1)(h) and Schedule 12, Part 2 – Condition 13(1)(h). Geophysical survey techniques may include use of high-resolution Side Scan Sonar (SSS), Multibeam Echosounder (MBES), magnetometer, Sub-Bottom Profiler (SBP), and Remotely Operated Vehicle (ROV). Geotechnical survey techniques may include use of boreholes, Cone Penetration Tests (CPTs), vibro-cores, acoustic corers and grab samples. Survey extents will cover the areas within which construction activity is proposed plus appropriate buffers to inform any micro-siting requirements.	Geophysical and geotechnical survey outputs may inform marine processes, benthic, shipping and navigation and archaeological monitoring and mitigation. Geotechnical survey outputs will inform the archaeological monitoring and mitigation.
Construction studies		
Footprint surveys	Studies required to ensure the safe placement of jack-up vessel legs on the seabed during construction. Techniques may include: Geophysical surveys using high resolution SSS, MBES, and ROV techniques. Survey extents will cover the areas within which construction activity is proposed.	Geophysical and geotechnical survey outputs may inform benthic and archaeological monitoring and mitigation.
Post-construction studies		
As-built surveys	Geophysical surveys (techniques as described under pre-construction phase) to confirm: • Cable burial success; • Adequate protection of buried assets, foundations and crossings; and • Presence of any dropped objects. Survey extents will cover the areas within which construction activity has taken place.	Geophysical and geotechnical survey outputs may inform benthic and archaeological monitoring and mitigation.
Operation and maintenance studies		
Asset protection studies	Periodic geophysical surveys to ensure that assets remain suitably buried and or protected and where necessary, inform the need for any remedial measures (re-burial / further protection etc). Techniques will be as described under pre-construction phase. 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.	Geophysical and geotechnical survey outputs may inform benthic and archaeological monitoring and mitigation.

Study and purpose	Description	Link to environmental 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. Survey extents will cover the areas within which construction activity using jack-up vessels is proposed.	Geophysical and geotechnical survey outputs may inform benthic and archaeological monitoring and mitigation.

3.3 Marine Geology, Oceanography and Physical Processes

3.3.1 Conclusions of the Environmental Statement

3.3.1.1 Changes to marine processes have the potential to indirectly impact other environmental receptors. For example, the creation of sediment plumes may lead to settling of material onto benthic habitats. Similarly, scour around foundations may lead to a loss of, or modification to, seabed habitat.

3.3.1.2 Whilst marine processes can largely be considered pathways for effects, some features have been identified as potentially sensitive marine processes receptors, such as offshore sandbanks including the Smithic Bank. All of the assessments of the potential impacts of Hornsea Four set out in **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes** were concluded to be likely to result in effects of negligible or slight adverse significance (not significant in EIA terms). This is, in part, due to the commitments made as described in **Volume A4, Annex 5.2: Commitments Register** and the present assumptions in the assessment being considered to offer a conservative assessment to offset uncertainties.

3.3.2 In-principle Monitoring Proposals

3.3.2.1 When taking account of the precautionary approach to assessment, there are considered to be no significant uncertainties in the assessment conclusions and therefore no monitoring requirements specifically related to marine processes have been identified, beyond the standard geophysical surveys which are outlined within **Table 2**. These surveys will inform a wide range of engineering elements relevant to the marine processes assessment, including changes in seabed topography and scour around foundations. Where these surveys are being undertaken as part of the standard pre-construction geophysical monitoring campaign, the specification of the surveys will be agreed with the MMO and its advisors during consultation in the post-consent phase.

~~3.3.2.1~~3.3.2.2 Whilst the assessment did not predict any significant effects, following requests from the MMO, Natural England and Cefas, the Applicant has committed to monitoring as set out in **Table 3** in relation to marine processes. It is anticipated that the methodologies for marine processes monitoring will follow established guidance on survey design and data interpretation and will be planned in consultation with the MMO and its statutory advisors.

~~3.3.2.2 No monitoring specific to different potential foundation types is proposed as part of the marine processes monitoring. Whilst monitoring of Gravity Base Structures (GBS) has been requested due to a perceived paucity of data due to the lack of data from monitoring in the UK, it is not considered that this represents a data gap due to the applicability of monitoring results from other wind farms within the wider southern North Sea region outside UK waters. Specifically, studies three to four years after the construction of the Thorntonbank Offshore Wind Farm in~~

~~Belgian waters reported significantly finer sediments (mean grain size) within 15 to 50 m of a GBS compared to sediments farther away from the foundations (>100 m), as well as along transects aligned with the principal tidal water flows (Coates et al., 2014). Within 15 m of the foundation and perpendicular to the principal tidal flow direction, it was reported that sediments were significantly coarser when compared to those further away. These observations were attributed, in part, to the effects of the construction of the offshore wind farm and to modification of the local hydrodynamic conditions as a result of the presence of the foundations. Tidal water flows around a GBS will be accelerated around its edges and reduced within its wake creating depositional and erosional conditions within the locale of the GBS depending on tidal orientation and current speeds (Coates et al., 2014).~~

~~3.3.2.3 A site specific assessment based on a combination of an evidence based approach, expert opinion, and project specific modelling was conducted to evaluate blockage related effects (and scour) from GBS within the Hornsea Four offshore array area (**Volume A5, Annex 1.1: Marine Processes Technical Report**). The assessment determined that similar magnitudes of scour would be likely around GBSs at Hornsea Four as that which has been studied at Thorntonbank.~~

~~3.3.2.3 Notwithstanding the above, as detailed previously, standard surveys which will be carried out pre- and post-construction irrespective of foundation type (as listed in **Table 2**) and will provide data on the impacts of GBSs (if used), with various acoustic surveys capable of being interpreted for the purposes of monitoring seabed changes, which would reveal changes in sediment transport associated with the presence of GBSs.~~

Table 3: Outline monitoring – marine processes.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
Pre-construction monitoring				
MP-O-1 MP-O-3 MP-O-4	Smithic Bank	Location: From the Holderness Coast (Mean Low Water Springs (MLWS)), across Smithic Bank and onto the Dogger Bank A & B Cable Crossing. Pre-construction survey across the width of all export cables, plus 10% buffer either side to help determine any up- or down-drift issues. Survey type: High-resolution multi-beam bathymetry. Reviews: Pre-construction survey reviewed to validate the baseline Smithic Bank and Dogger Bank A & B cable crossing).	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To provide a baseline of the Smithic Bank and the Dogger Bank A & B cable crossing.
Post-construction monitoring				
MP-O-1 MP-O-3 MP-O-4	Smithic Bank	Location: From the Holderness Coast (MLWS), across Smithic Bank and onto the Dogger Bank A & B Cable Crossing. Surveys every six months for the first three years (asset crossing), requirement for further surveys reviewed thereafter. Survey at the width across all export cables, plus 10% buffer either side to help determine any up- or down-drift issues. Survey type: High-resolution multi-beam bathymetry. Post-construction surveys are reviewed against pre-construction survey to determine any change. Reviews reported annually to MMO. Any notable changes will need to consider natural variability (such as seabed response to metocean events) and potential influences due to installed structures.	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To record any potential changes to Smithic Bank arising from the construction of Hornsea Four.
MP-O-2 MP-O-3	Flamborough Front	**Near-Field Monitoring** Location: In the lee wake of three GBS foundations (if used) across Hornsea Four array, notionally; one WTG-GBS, one Box-type GBS Large (150 m width), and one Box-type GBS Small (75 m width). Single survey, ideally during spring tides, to coincide with times of peak flood or ebb flow (maximum wake effect) during a period of summer stratification. Survey type: Towed thermistor chain (comparable to the field surveys conducted by Schultze *et al*, (2020) and Acoustic Doppler Current Profiler (ADCP). Transects across observed wake at 100 m intervals downstream of each foundation to a maximum of 1,000 m. Data to be reported as an industry publication to on the scale and intensity of wake related effects from larger foundation types (GBS only) (determined by towed ADCP) and the consequence of	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To determine the scale and intensity of near-field wake-related effects from GBS foundations and ascertain the need for far-field monitoring.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
		increased turbulent mixing (maximum of 500m from foundation centre) within the wake on vertical thermal stratification (determined by thermistor chain). If Hornsea Four adopts any other consented foundations rather than GBS then this monitoring requirement does not apply. Interventions: Not applicable. Should turbulent wakes exceed those predicted in the EIA, this will trigger far-field (array-scale) monitoring. The near-field survey will be planned to ensure that survey objectives are met and activated when specific environmental criteria occur, notably the presence of stratification across the offshore array area, as determined from Sentinel 3 reconnaissance surveys. The following details provide an outline plan: • The survey will occur during the summer period when seasonal stratification has fully developed and the Flamborough Front has formed (peak front formation is July). • The survey will only be activated when the alignment of the Flamborough Front is either across or south of the offshore array area. If the front remains to the north then no stratification be will present within the offshore array area and the survey will remain pending. • The location of the front will be determined by suitable satellite observations of sea surface temperature (e.g. Sentinel 3) which are available in near real-time. A monthly summary of the location of the front will be developed for the summer period. If the front is consistently found to be north of the offshore array area after three consecutive summer periods then the near-field survey will no longer be required and all associated obligations related to conducting this survey will be considered as fully met. • If the front has developed within or to the south of the offshore array area (as indicated by available satellite data) then the survey contractor will be notified to mobilise to site. At the same time Natural England, MMO and Cefas will be notified of the intent to conduct the near-field survey based on meeting the relevant environmental criteria. • The target locations for survey relate to specific GBS sites which reside within the area considered to be experiencing stratification. Potential targets will be considered once a final layout has been established to aid survey planning. • The survey will be conducted during daylight hours at times of peak flows (either ebb or flood tide) to determine the extent of any wakes stemming from GBS foundations. The survey will not		

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
		be restricted to spring tides or periods of low cloud cover, although these conditions are preferred to establish maximum extents of wakes and to synchronise with a satellite over-pass.		
MP-O-2 MP-O-3	Flamborough Front	**Far-Field Monitoring** Far-field monitoring would only be required should the near-field monitoring confirm turbulent wakes in exceedance of those predicted in the EIA. Location: The Hornsea Four array area to establish any array scale effects. Survey type: • Part 1: Evaluation of relevant satellite images that represent sea surface temperature, e.g. Sentinel 3. • Part 2: Evaluation of relevant satellite images that represent chlorophyll concentrations, e.g. Sentinel 3. • N.B: Satellite image resolution is 1,000 m for sea surface temperature and 300 m for chlorophyll which limits this approach to discerning array scale effects rather than individual wake effects. Survey frequency: Sentinel 3 already has a data bank that will cover the pre-construction period. Initial interest in post-construction period and timed with the near-field survey. Overpass tracks from Sentinel 3 repeat every 27 days but the large swath widths of 1,270 km enable images to be available every 1.4 days (Sentinel 3A and 3B). Images only provide useable data where there is no cloud cover. Bi-monthly composite images for an initial period of 12 months to represent seasonal variations. Reviews: • Part 1: The far-field hypothesis requires a net reduction in sea surface temperature to be detectable across the Hornsea Four array area relative to the temperature of undisturbed surrounding water. A provisional reduction of 2°C relative to the average temperature of surrounding water is proposed (the level of temperature reduction during seasonal stratification needs to be confirmed with consideration to natural variations from pre-construction periods and the magnitude of the thermocline as established from available 3D modelling) (phase 1) • Part 2: If there is a detectable change in water temperature above the ambient background for an attributable effect at the array scale (Part 1) then the analysis will extend to examining chlorophyll concentrations as a proxy for influences on primary production (Part 2). A standalone report will be prepared covering a pre-construction baseline characterisation (1 year), construction (1 years) and a post-construction/operational (1 year) comparison.	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To determine the scale and intensity of far-field wake-related effects from GBS foundations.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
		This work is planned to tie in with the requirements for near-field surveys. If near-field surveys confirm the localised extent of wakes has no discernible temperature reduction which develop as cold water plumes then the far-field effect monitoring is not required. Present assumptions linked to the availability of Sentinel 3 satellite images. It is acknowledged that this subject may be a subject of proposals to the ECOWind programme and will provide evidence if progressed.		
N/A	Drill mounds	Should drilling be utilised to install piled foundations, the Applicant will make best endeavours to ensure no drill mounds (i.e. sediment arising from the drilling of Hornsea Four foundations) persists above 3m from the surrounding seabed. In the event that such drill mounds greater than 3m are found to persist, an appropriate monitoring campaign will be developed in consultation with the MMO and its statutory advisors.	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To monitor the persistence of drill mounds on the seabed.

3.4 Benthic Subtidal and Intertidal Ecology

3.4.1 Conclusions of the Environmental Statement

3.4.1.1 The potential impacts of Hornsea Four on benthic subtidal and intertidal ecology are set out in **Volume A2, Chapter 2: Benthic and Intertidal Ecology**, including those related to temporary habitat loss and disturbance and the long-term presence of the infrastructure on the seabed. It was concluded that, for all of the potential impacts considered, resulting effects will be of neutral or slight adverse significance (not significant in EIA terms), with no significant uncertainties arising.

3.4.1.2 Whilst the assessment did not predict any significant effects, it is recognised that there are commitments (as an embedded mitigation measure) to avoid priority habitats under Section 41 of the Natural Environment and Rural Communities Act (2008), such as potential biogenic or geogenic reef, through micro-siting cables and foundations. The relevant commitments (related to monitoring only) are outlined in **Table 4**, with full details provided in **Volume A4, Annex 5.2: Commitments Register**.

Table 4: Relevant monitoring benthic subtidal and intertidal ecology commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co48	Primary: Habitats of principal importance (Section 41 of the 2006 Natural Environment and Rural Communities (NERC) Act) will be avoided where possible, informed through the undertaking of survey works pre-construction.	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets - Part 2 - Condition 13(1)(a); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 13(1)(a) (Pre-construction plans and documentation)
Co84	Primary: Presence of habitats of principal importance (Section 41 of the 2006 Natural Environment and Rural Communities (NERC) Act) will be identified through a review of the latest available benthic datasets and pre-construction surveys. Foundations and cables will be micro-sited around habitats of principal importance wherever reasonably practicable (subject to agreement with the MMO) to an extent not resulting in a hazard for marine traffic and Search & Rescue capability.	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets - Part 2 - Condition 13(1)(a)(v); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 13(1)(a)(v) (Pre-construction plans and documentation)

3.4.2 In-principle Monitoring Proposals

3.4.2.1 **Table 5** provides information on the outline monitoring proposed for benthic subtidal and intertidal ecology for Hornsea Four. It is anticipated that the methodologies for benthic ecology monitoring will follow established guidance on survey design and data interpretation and will be planned in consultation with the MMO and its statutory advisors.

Table 5: Outline monitoring – benthic subtidal and intertidal ecology.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
Pre-construction monitoring				
BIE-C-1 BIE-C-3	Potential habitats of principle importance (Section 41 of the NERC Act)	Full sea floor coverage swath bathymetry survey within the areas within which construction works are proposed to determine the location, extent and composition of any potential habitats of principle importance (Section 41 of the NERC Act) including biogenic or geogenic reef features (as defined by Irving (2009) and Gubbay (2007) and in Table D1 of Appendix D of **Volume A5, Annex 2.1: Benthic Subtidal and Intertidal Ecology Technical Report**). Targeted Drop-Down Video (DDV) survey to confirm the presence, nature and extent of any potential habitats of principle importance (Section 41 of the NERC Act) features identified in the pre-construction geophysical data. Benthic DDV surveys may be undertaken up to 12 months prior to the commencement of offshore construction works (exact timings to be agreed post-consent with the MMO and its advisors).	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 17(2)(a); and Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 17(2)(a) (Pre-construction monitoring and surveys)	Ensure in so far as possible that any areas of habitats of principle importance (Section 41 of the NERC Act) are avoided (where reasonably practicable) from direct disturbance by construction activity.
BIE-C-6 BIE-O-11	Sediment sampling	In the event that the pre-application Particle Size Analysis (PSA) results have not been approved by the MMO prior to DCO award, no disposal activities associated with Hornsea Four will take place until the MMO have provided this approval in writing.	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To ensure sediments are suitably characterised prior to disposal of dredged materials at sea.
Post-construction monitoring				
BIE-O-8 BIE-O-11 BIE-O-13	Potential habitats of principle	Where pre-construction surveys confirm the presence of potential habitats of	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation	To record any potential changes to the habitats of principle importance (Section 41

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
	importance (Section 41 of the NERC Act)	principle importance (Section 41 of the NERC Act) in the areas surveyed during the pre-construction surveys, targeted swath bathymetry and DDV survey of previously identified habitats of principle importance will be undertaken. The aims of which are to identify any changes to the location, extent and composition of any potential habitats of principle importance (Section 41 of the NERC Act) identified during pre-construction surveys.	Assets – Part 2, Condition 19(2)(a); Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 19(2)a) (Post-construction monitoring)	of the NERC Act) identified during the pre-construction surveys arising from the construction of Hornsea Four.
BIE-O-13	Changes to benthic community structure as a result of foundation installation	Undertake monitoring of the benthic communities comprising grab samples in the form of a cruciform design at one of each GBS foundation type. The location of the monitored GBS would be identified following the post-construction geophysical survey and would be the location with the greatest level of scour for each foundation type. Analysis of sample data to determine potential changes to the benthic community structure from before and after construction.	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To identify any potential changes to the benthic community structure from before and after construction in relation to GBS foundations.
BIE-O-10	Non-Native Invasive Species	Undertake monitoring of the benthic communities comprising grab samples and video around foundations. Analysis of sample data to determine species composition and the presence of any marine non-native species. NB: The foundation locations for this monitoring will be the foundations monitoring in relation to those selected for the 'Changes to benthic community structure as a	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To investigate the potential presence of marine non-native invasive species on GBS foundations.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
		result of foundation installation' monitoring above.		
BIE-O-8	Drill mounds	Should drilling be utilised to install piled foundations, the Applicant will make best endeavours to ensure no drill mounds (i.e. sediment arising from the drilling of Hornsea Four foundations) persists above 3m from the surrounding seabed. In the event that such drill mounds greater than 3m are found to persist, an appropriate monitoring campaign will be developed in consultation with the MMO and its statutory advisors.	Schedule 15 of C1.1 Draft DCO including Draft DML, Part 3, Other Documents to be Certified (the outline marine monitoring plan).	To monitor the persistence of drill mounds on the seabed.

~~3.4.2.2 No monitoring specific to different foundation types is proposed as part of the benthic monitoring. Whilst monitoring of GBS foundations has been requested due to a perceived paucity of data from monitoring in the UK, it is not considered that this represents a data gap due to the applicability of monitoring results from other wind farms where GBS foundations have been installed within the wider southern North Sea biogeographic region. The application of GBS within UK windfarms has, to date, been limited to the Blyth Demonstrator site where five turbines were installed using GBS. Benthic monitoring was not undertaken at this site.~~

~~3.4.2.3 However, GBS have been installed and their effects on the benthos monitored at Thorntonbank Offshore Wind Farm, a Belgian site in the southern North Sea. Studies three to four years after the construction of Thorntonbank reported significantly finer sediments (mean grain size) within 15 to 50 m of a GBF compared to sediments sampled farther away (>100 m), as well as along transects aligned with the principal tidal water flows (Coates et al., 2014). Within 15 m of the foundation and perpendicular to the principal tidal flow direction, it was reported that sediments were significantly coarser when compared to those further away. These observations were attributed, in part, to the effects of the construction of the offshore wind farm and to modification to the local hydrodynamic conditions as a result of the presence of the foundation. Tidal water flows around a GBS will be accelerated around its edges and reduced within its wake creating depositional and erosional conditions within the locale of the GBS depending on tidal orientation and current speeds (Coates et al., 2014).~~

~~3.4.2.4 Increased organic matter content within the seabed sediments sampled at sites within 15 to 50 m of a GBS compared to sediments sampled at greater distances (>100 m) were attributed to sinking detritus and faeces from the epibenthic communities colonising the GBS (Coates et al., 2014). The changes in sediment character (grain size and organic content) resulted in the macrobenthic community in the vicinity of the GBS evolving away from the original (*Nephtys cirrosa*) community (Coates et al., 2014). At 1 m and 7 m from the foundation, high densities of juvenile common starfish (*Asterias rubens*) and two hard substrate amphipods (*Monocorophium acherusicum* and *Jassa herdmani*) were sampled, highlighting the direct effect of the presence~~

~~of the hard substrate provided by the GBS. Alongside these hard substrate species, two polychaete worms (*Lanice conchilega* and *Spiophanes bombyx*), common to soft substrate, dominated the community but in high abundances. Strong spatial and annual variability of the macrofaunal densities suggests that benthic communities in the immediate vicinity of the GBS during the monitoring period were unstable and had not yet established.~~

~~3.4.2.5 The results from the study at Thorntonbank show a strong similarity to a study carried out around a GBS within a Danish offshore wind turbine where the biomass and abundance of fauna also enriched the sediments along one gradient due to the depositional flow from Blue mussel (*Mytilus edulis*) colonies which accounted for 97-99% of the hard substrate epifauna in the infralittoral zone of the GBS (Maar et al., 2009).~~

~~3.4.2.6 For Hornsea Four, a site specific assessment based on a combination of an evidence based approach, expert opinion, and project specific modelling was conducted to evaluate blockage related effects (and scour) from GBS within the Hornsea Four offshore array area (**Volume A5, Annex 1.1: Marine Processes Technical Report**). The assessment determined that similar magnitudes of scour would be likely around GBSs at Hornsea Four as that which has been studied at Thorntonbank. Therefore, the results from the benthic monitoring conducted at Thorntonbank are considered to provide a reasonable indication of the effects on the benthic communities that might be expected at Hornsea Four in the event that GBS are deployed, noting that the effects recorded at Thorntonbank were spatially highly localised to each structure.~~

~~3.4.2.7 Notwithstanding the above, standard surveys which will be carried out pre- and post-construction, irrespective of foundation type, and as summarised in **Table 2**, will provide data on the impacts of GBSs on the seabed environment (if used), with various acoustic surveys capable of being interpreted for the purposes of monitoring seabed changes, which would reveal changes in sediment transport associated with the presence of GBSs which may be interpreted to predict associated changes in the benthic communities.~~

3.5 Fish and Shellfish Ecology

3.5.1 Conclusions of the Environmental Statement

3.5.1.1 The characterisation of the baseline environment conducted to inform the EIA process, using both the results of surveys from the former Hornsea Zone and a desk-based literature review identified that the species assemblage of the Hornsea Four fish and shellfish ecology study area can be considered typical of this region of the southern North Sea (see **Volume A5, Annex 3.1: Fish and Shellfish Ecology Technical Report**).

3.5.1.2 The potential impacts on fish and shellfish receptors from all stages of Hornsea Four were assessed, and with relevant commitments and embedded mitigation considered, all resulting effects were concluded to be of neutral or slight adverse significance (not significant in EIA terms) (see also **Volume A2, Chapter 3: Fish and Shellfish Ecology**).

3.5.2 In-principle Monitoring Proposals

3.5.2.1 Whilst the assessment did not predict any significant effects, following a request from Cefas, the Applicant has committed to sediment monitoring in relation to herring and sandeel spawning habitat, as detailed in **Table 6**.

Table 6: Outline monitoring – fish and shellfish ecology.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
Pre-construction monitoring				
FSE-C-2	Herring and Sandeel	Targeted Particle Size Analysis (PSA) survey within the export cable corridor along planned cable routes and adjacent areas – focused on cable sections where it is thought that flow tools may be required (e.g. sandwaves or more challenging ground conditions) to provide a baseline of the sediment suitability within the cable corridor for herring and sandeel spawning (as defined by Reach et al. (2013) and Latto et al. (2013) for herring and sandeel, respectively).	This monitoring will be secured by the final Marine Monitoring Plan. Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 17; Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 17 (Pre-construction monitoring and surveys)	To provide a baseline of the suitability of the sediment in these areas for herring and sandeel spawning.
Post-construction monitoring				
FSE-C-2 FSE-O-18	Herring and Sandeel	Where flow tools have been used along pre-surveyed areas, a targeted PSA survey using the same survey locations as for the pre-construction survey to enable any changes in sediment suitability for spawning for herring and sandeel to be determined.	This monitoring will be secured by the final Marine Monitoring Plan. Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 19; Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 19 (Post-construction monitoring)	To enable identification of any areas where construction activities have altered the sediment characteristics and to allow an assessment of suitability for continued spawning activity.

3.6 Marine Mammals

3.6.1 Conclusions of the Environmental Statement

3.6.1.1 Underwater noise from foundation piling and clearance of UXO has the potential to cause injury or disturbance to marine mammals. The most sensitive marine mammal species across the Hornsea Four marine mammals study area is considered to be harbour porpoise (**Volume A2, Chapter 4: Marine Mammals**). Appropriate commitments have been made as part of the project design to prevent significant impacts for injurious and lethal effects through the adoption of a Marine Mammal Mitigation Protocol (MMMP – Co110)) (see **F2.5: Outline Marine Mammal Mitigation Protocol**). Specifically in relation to the Southern North Sea Special Area of Conservation (SAC) designated for harbour porpoise, the Applicant has also committed to the submission of a Site Integrity Plan (SIP) for approval prior to commencement, an outline of which has been provided with the DCO Application (**F2.11: Outline Southern North Sea Special Area of Conservation Site Integrity Plan**) to ensure that the conclusion of no Adverse Effect on Integrity (no AEoI) on the conservation objectives of the site, remains valid.

3.6.1.2 With the implementation of the plans described in the paragraphs above, and the commitments made in **Volume A4, Annex 5.2: Commitments Register**, all effects on marine mammals were concluded to be of neutral or slight adverse significance (not significant in EIA terms), taking into account the precautionary approach to assessment regarding any uncertainties.

3.6.2 In-principle Monitoring Proposals

3.6.2.1 **Table 7** below provides information on the outline monitoring for marine mammals.

Table 7: Outline monitoring – marine mammals.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
Construction monitoring				
MM-C-1 MM-C-3	All marine mammals	Monitoring to validate the underwater noise modelling that underpins the impact assessment. Measurements of noise generated by the installation of first 4 foundations of each driven or part-driven pile foundations to be constructed collectively under the Generation and Transmission DMLs. The transects monitored in the survey will be informed by the predictions for noise propagation within the ES, with transects planned to ensure validation of the underwater noise towards or over deeper water around the monitored turbines.	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 18)(2)(a); and Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 18(2)(b). (Construction monitoring)	To validate the underwater noise propagation modelling and thereby ensure that the mitigation measures as detailed within the Marine Mammal Mitigation Protocol (in line with **F2.5 Outline Marine Mammal Mitigation Protocol**) are sufficient to ensure no risk of injury to marine mammals.
	All marine mammals	Monitoring by marine mammal observers prior to start of piling as part of the Marine Mammal Mitigation Protocol (**F2.5 Outline Marine Mammal Mitigation Protocol**). Monitoring will be undertaken for at least 30 minutes prior to the commencement of the soft-start of piling.	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 – Condition 13(1)(g); and Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 – Condition 13(1)(g). (Pre-construction plans and documentation)	To provide visual confirmation by a trained marine mammal observer that no marine mammals are present within the immediate vicinity of the planned piling activity.

3.6.2.2 In addition to the above monitoring proposals, through consultation it is recognised that additional monitoring may be required for marine mammals within the Southern North Sea SAC, depending on the further assessments provided during the development of the SIP for the Southern North Sea SAC, as detailed within **F2.11: Outline Southern North Sea Special Area of Conservation Site Integrity Plan**.

3.6.2.3 Finally, in addition data on the distribution, abundance and diversity of marine mammals will be provided as a result of the pre- and-post construction digital aerial surveys where these are

undertaken as part of the ornithological monitoring within the Hornsea Four site and across an appropriate buffer area (see Table 8 below for further details).

3.7 Offshore Ornithology

3.7.1 Conclusions of the Environmental Statement

3.7.1.1 A number of potential impacts on offshore ornithology have been identified, as detailed in **Volume A2, Chapter 5: Offshore and Intertidal Ornithology**, including those related to disturbance and displacement, and collision risk. It was concluded that, for all of the potential impacts considered, resulting effects will be of neutral or slight adverse significance (not significant in EIA terms).

3.7.2 In-principle Monitoring Proposals

3.7.2.1 Whilst the assessment did not predict any significant effects, it is recognised that uncertainties exist, generically, within the ornithological assessment process relating to, for example, flight heights, demographics, apportioning of populations from SPAs, foraging ranges and avoidance rates[2]. In order to address these uncertainties, precautionary approaches have been taken to assessments with a range of parameters often used (e.g. within the Collision Risk Modelling) to account for these uncertainties.

3.7.2.2 An Outline Ornithological Monitoring Plan (OOMP) has been submitted as part of the DCO Application (**F2.19: Outline Ornithological Monitoring Plan**) which contains details of the proposed outline monitoring approach and associated justification, and as such, only a high-level summary of these proposals is presented in **Table 8**. It is important to note that the OOMP relates to EIA-related monitoring only. Any monitoring associated with a Regulation 64 derogation under the provisions of the Habitats Regulations will be considered separately.

3.7.2.3 The OOMP will be updated in the post-consent phase, prior to the commencement of offshore construction (in consultation with the MMO and the relevant statutory nature conservation body, Natural England) to ensure that the final OOMP submitted for approval remains appropriate to the final design of the scheme and the relevant uncertainties. The final OMMP will be based on the principles adopted in the OOMP, with the aim of addressing uncertainty, where it is possible and reasonable for those uncertainties to be monitored at Hornsea Four (it is, for the avoidance of doubt, not the intention of the DML condition or the outline proposals to provide an exhaustive monitoring exercise to address all of the uncertainties alluded to in **paragraph 3.7.2**).

Table 8: Outline monitoring – offshore ornithology.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
Pre-construction and construction monitoring				
ORN-O-5 *ORN-O-6*	Guillemots, razorbills and puffins	Monitoring to determine the at-sea distribution of the relevant species prior to and during construction. Digital aerial surveys will be undertaken between Hornsea Four	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 – Condition 17(2)(b).	Establish important sea areas relative to Hornsea Four for these species, provide a baseline

[2] It is also recognised that at project and strategic levels, there are and will be a number of studies underway aimed at addressing aspects of these generic uncertainties and that the outcomes of these studies and the resulting body of evidence will need to be taken into account when designing the final Hornsea Four OMMP.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
		and the Flamborough and Filey Coast SPA during the extended breeding season. The survey parameters will be informed by a power analysis.	(Pre-construction monitoring and surveys)	for post-construction monitoring and support data being collected for other Hornsea projects.
Post-construction monitoring				
ORN-O-5 *ORN-O-6*	Guillemots, razorbills and puffins	Monitoring to determine the at-sea distribution of the relevant species post-construction. Digital aerial surveys will be undertaken between Hornsea Four and the Flamborough and Filey Coast SPA during the extended breeding season, for up to five years post-construction.	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 – Condition 19(2)(c). Post-construction monitoring and surveys)	Establish important sea areas relative to Hornsea Four for these species, determine if predicted effects on these species were valid and support data being collected for other Hornsea projects.
ORN-O-6	Gannets and kittiwakes	Monitoring to determine avoidance of turbines by these species. Multi-sensor systems could be explored to determine suitability for use to validate avoidance rates used within the assessment or determination of flight heights within and around Hornsea Four.		Enable determination of the suitability of the avoidance rates and flight heights assumed within the assessment and whether the predicted effects on these species were valid.
N/A	Gannets, kittiwakes and guillemots, razorbills and puffins	A variety of surveys to monitoring whether individuals at or around Hornsea Four are attributable to the Flamborough and Filey Coast SPA, age structure of individuals at the SPA, undertake colony counts at the SPA, long-term ring-resighting and productivity studies at the SPA.		Enable determination of the suitability of attribution rate of each species

3.8 Commercial Fisheries

3.8.1 Conclusions of the Environmental Statement

3.8.1.1 The potential impacts of Hornsea Four on commercial fisheries have been assessed within **Volume A2, Chapter 6: Commercial Fisheries** and all resulting effects were concluded to be of negligible or slight adverse significance (not significant in EIA terms).

3.8.2 In-principle Monitoring Proposals

3.8.2.1 In line with Co95 (**Volume A4, Annex 5.2: Commitments Register**), a Fisheries Co-existence and Liaison Plan will be developed in accordance with the principles set out in the Outline Fisheries

Co-existence and Liaison Plan submitted as part of the DCO Application (**F2.9: Outline Fisheries Co-existence and Liaison Plan**), prior to the commencement of offshore construction.

3.8.2.2 Given the lack of significant effects on commercial fisheries receptors attributable to Hornsea Four alone, and lack of any significant uncertainty, no monitoring has been proposed, noting that a post-construction survey will be undertaken to identify and where necessary, remove any construction related debris that may present a risk to fishing activity. In line with Part 2, Condition 11(10) of Schedules 11 and 12 of **C1.1 Draft DCO indulging Draft DML**, the Applicant has committed to following a Dropped Objects Procedure, requiring the removal of obstructions from the seabed, if reasonable to do so.

3.9 Shipping and Navigation

3.9.1 Conclusions of the Environmental Statement

3.9.1.1 The potential impacts of Hornsea Four on shipping and navigation have been considered and are described in **Volume A2, Chapter 7: Shipping and Navigation** and **Volume A5, Annex 7.1: Navigational Risk Assessment (NRA)**. All residual effects were concluded to be of neutral or slight adverse significance (not significant in EIA terms), with no significant uncertainties identified.

3.9.2 In-principle Monitoring Proposals

3.9.2.1 Whilst the assessment did not predict any significant effects, the project will comply with the requirements of Marine Guidance Note (MGN) 654 (Maritime and Coastguard Agency (MCA) 2021), which contains standard requirements for pre- and post-construction monitoring (Co99) to ensure that commitments (embedded mitigation) are deployed effectively and are managing navigation safety including that routeing patterns around the site have aligned with the predictions of the Navigational Risk Assessment. **Table 9** provides information on the outline monitoring proposed for shipping and navigation.

Table 9: Outline monitoring – shipping and navigation.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring
Pre-construction monitoring and surveys			
SN-O-7	All shipping traffic	High resolution swathe bathymetric surveys as described in **Table 4** will be undertaken to provide a baseline of bathymetry in those areas within which construction activity will take place, and to inform future navigation risk assessments as part of the cable specification and installation plan. All hydrographic surveys will fulfil the requirements of the MCA's 'Hydrography Guidelines for Offshore Developers' and 'Post-Construction Hydrographic Guidelines for Offshore Developers'.	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 17(2)(a); and Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 17(2)(a). (Pre-construction monitoring and surveys)
Construction monitoring			
SN-C-1	All shipping traffic	Vessel traffic monitoring by use of Automatic Identification System (AIS) data will be undertaken for the duration of the construction period to monitor any changes in pre-construction	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 18(2)(b); and

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring
		vessel routes and to validate the predictions made in the Application (including those of the NRA).	Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 18(2)(a). (Construction monitoring)
Post-construction monitoring			
SN-O-7	All shipping traffic	Post construction geophysical surveys (see Table 2) will be used to ensure cables or indeed other subsea elements are not left exposed and/or unmarked in order to, amongst other things; reduce snagging risk to anchors and fishing gear. All hydrographic surveys will fulfil the requirements of the MCA's 'Hydrography Guidelines for Offshore Developers' and 'Post-Construction Hydrographic Guidelines for Offshore Developers'.	Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2, Condition 19(2)(b); and Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2, Condition 19(2)b) (Post-construction monitoring)

3.10 Marine Archaeology

3.10.1 Conclusions of the Environmental Statement

3.10.1.1 The potential impacts of Hornsea Four on marine archaeology have been considered and are described in **Volume A2, Chapter 9: Marine Archaeology**. All residual effects were concluded to be of neutral or slight adverse significance (not significant in EIA terms), with no significant uncertainties identified.

3.10.2 In-principle Monitoring Proposals

3.10.2.1 Whilst the assessment did not predict any significant effects, it is recognised that there are commitments (as an embedded mitigation measure) to identify any marine archaeological features that require mitigation, and secondary monitoring post-construction to establish the effectiveness of Archaeological Exclusion Zones (AEZs) implemented prior to construction (Co46 and Co140). The relevant commitments are outlined in **Table 10**, with further details provided in **Volume A4, Annex 5.2: Commitments Register**.

Table 10: Relevant marine archaeology commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co140	Tertiary: A Marine Written Scheme of Archaeological Investigation (WSI) will be developed in accordance with the Outline Marine WSI. The Marine WSI will include the requirement for Archaeological Exclusion Zones (AEZs) to be established to protect any known / identified marine archaeological receptors and the implementation of a Protocol for Archaeological Discoveries (PAD) in accordance with 'Protocol for Archaeological Discoveries: Offshore Renewables Projects' (The Crown Estate 2014).	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 - Condition 13(2) & 13(3); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 13(2) &13(3) (Marine Written Scheme of Archaeological Investigation)
Co166	Secondary: An offshore geophysical survey (including an Unexploded Ordnance (UXO) survey) will be undertaken prior to construction and will be subject to a full archaeological review in consultation with Historic England.	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 - Condition 13(2) and 13(3); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 13(2) and 13(3) (Marine Written Scheme of Archaeological Investigation)
Co167	Secondary: An offshore geotechnical survey will be undertaken prior to construction, including a staged geoarchaeological assessment and analysis of geotechnical data inclusive of publication, in consultation with Historic England.	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 - Condition 13(2) and 13(3); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 13(2) and 13(3) (Marine Written Scheme of Archaeological Investigation)

3.10.2.2 The need for and scope of monitoring associated with the historic environment will be set out within the Marine Written Scheme of Investigation (WSI), including an appended Protocol for Archaeological Discoveries (PAD). An Outline Marine WSI (**F2.4: Outline Marine Written Scheme of Investigation**) has been submitted as part of the DCO application. The document will be monitored and updated throughout the post-consent process, prior to the commencement of offshore construction (in consultation with Historic England) to ensure that the WSI remains appropriate to the final design of the scheme and to incorporate the results of any relevant pre-construction monitoring surveys (such as, for example, high resolution swath bathymetric pre-construction surveys). Prior to construction, the Marine WSI will be finalised and submitted to the MMO for approval in consultation with Historic England.

Table 11: Outline monitoring – marine archaeology.

Impact ID	Receptor(s)	Monitoring approach and objectives	Method of securing monitoring	Monitoring rationale
Pre-construction monitoring				
MA-O-7 MA-O-8	Archaeological features	Full coverage bathymetry surveys (as described in Table 5) within which construction activity will take place. Survey scopes and data will be reviewed by an accredited archaeologist. Baseline identification of marine archaeological features to inform the WSI will provide for the establishment of AEZs, where required.	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 - Condition 17(2)(a); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 17(2)(a). (Pre-construction monitoring and surveys)	Ensure the identification of any items of archaeological interest to facilitate micrositing of infrastructure or other mitigation strategies. In compliance with the WSI.
Post-construction monitoring				
MA-O-7 MA-O-8	Archaeological features	Following review of construction activity, post-construction bathymetric monitoring (Table 2) of AEZs will be undertaken to ensure that there are no negative impacts to AEZs from construction activities.	DCO Schedule 11, Deemed Marine Licence Under The 2009 Act – Generation Assets – Part 2 - Condition 19(2)(b); and DCO Schedule 12, Deemed Marine Licence Under The 2009 Act – Transmission Assets – Part 2 - Condition 19(2)(b). (Post-construction monitoring)	Enable confirmation of mitigation measures being successful.

4 References

Cefas. 2012. Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects. Cefas contract report: ME5403 – Module 15.

~~Coates, D.A., Deschutter, Y., Vincx, M and Vanaverbele, J. 2014. Enrichment and shifts in microbenthic assemblages in an offshore wind farm in the Belgium part of the North Sea. Mar. Env. Res. 95; 1-12.~~

Glasson J, Therivel R and Chadwick A. 2011. Introduction to Environmental Impact Assessment. 4th edition. The Natural and Built Environment Series.

Irving R 2009 The identification of the main characteristics of stony reef habitats under the Habitats Directive. JNCC Rep No 432:44.

Latto, P. L. Reach, I.S. Alexander, D. Armstrong, S. Backstrom, J. Beagley E. Murphy, K. Piper, R. and Seiderer, L.J. 2013 Screening spatial interactions between marine aggregate application areas and sandeel habitat. A Method Statement produced for BMAPA.

~~Maar, M., Bolding, K., Petersen, J., Hansen, J. and Timmermann, K. 2009. Local effects of blue mussels around turbine foundations in an ecosystem model of Nysted off-shore wind farm, Denmark. Journal of Sea Research. 62. 159-174. 10.1016/j.seares.2009.01.008.~~

MMO 2014a. Review of Post-Consent Offshore Wind Farm Monitoring Data Associated with Licence Conditions MMO Project No: 1031.

MMO 2014b. The Marine Management Organisation (MMO) Response to an Independent Review of Environmental Data Collected at UK and European Offshore Wind Farms and 22 Recommendations for Future Post-Consent Monitoring.

Ministry of Housing, Communities and Local Government, 2019. National Planning Policy Framework [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf [Accessed: October 2020].

OSPAR. 2008. Guidance on Environmental Considerations for Offshore Wind Farm Development. Available at: [redacted] [Accessed October 2020].

Reach, I.S., Latto, P., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R. and Seiderer, L.J., 2013. Screening spatial interactions between marine aggregate application areas and atlantic herring potential spawning areas. A Method Statement produced for BMAPA.

Schultze, L. K. P., Merckelbach, L. M., Horstmann, J., Raasch, S., & Carpenter, J. R. (2020). Increased mixing and turbulence in the wake of offshore wind farm foundations. Journal of Geophysical Research: Oceans, 125, e2019JC015858. [redacted]