Hornsea Project Four: Environmental Statement (ES)

Fish Habitat Enhancement Project Description

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Table of Contents

List of Tables

List of Figures

Glossary

Term	Definition
Commitment	Hornsea Four, throughout the pre-Application consultation process, has produced a Commitments Register which forms a quick reference guide to commitments the project has made. Commitment is a term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Compensation Measures	The measures that have been developed by the Applicant pursuant to the HRA Derogation Provisions "without prejudice" to the Applicants position of no Adverse Effect on Site Integrity at the Flamborough and Filey Coast in respect of the qualifying features. The Compensation Measures are: [offshore and onshore nesting; predator eradication; bycatch and fish habitat enhancement measures]. Each a Compensation Measure and together Compensation Measures.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Project Four.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Four design options under consideration, as set out in detail in the project description and this Compensation Project Description. This envelope is used to define Hornsea Project Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
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, connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Landfall	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) tide and the Transition Joint Bay (TJB) inclusive of all construction

	works, including the offshore and onshore ECC, intertidal working area and landfall compound. Where the offshore cables come ashore east of Fraisthorpe.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
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, or PEIR or ES).
Order Limits	The limits within which Hornsea Project Four (the 'authorised project) may be carried out.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).

Acronyms

Term	Definition
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
HRA	Habitats Regulations Assessment
MDS	Maximum Design Scenario
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
PEIR	Preliminary Environmental Information Report
PINS	The Planning Inspectorate
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SPA	Special Protection Area
SSS	Side-Scan Sonar
TCE	The Crown Estate
UKHO	UK Hydrographic Office

Units

Unit	Definition
dB	Decibel (sound pressure)
Hz	Hertz (frequency)

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Limited (the 'Applicant') is proposing to develop Hornsea Project Four Offshore Wind Farm ('Hornsea Four').

1.1.1.2 The purpose of this Environmental Impact Assessment (EIA) Project Description Annex is to provide a description of the proposed Compensation Measures the Applicant may be required to deliver to compensate for potential impacts upon certain seabird species at the Flamborough and Filey Coast Special Protection Area (FFC SPA), located on the East Coast of England. The Compensation Measures are proposed "without prejudice" to the Applicant's conclusion of No Adverse Effect on Integrity (AEoI) upon the seabird species (kittiwake, gannet, guillemot and razorbill) in the Report to Inform the Appropriate Assessment (RIAA).

1.1.1.3 The Hornsea Four offshore wind farm will be located approximately 69 km offshore 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 (at Fraisthorpe), and connection to the electricity transmission network at National Grid Creyke Beck. Detailed information on the project design can be found in **Volume 1: Project Description**, with detailed information on the site selection process and consideration of alternatives described in **Volume 1: Site Selection and Consideration of Alternatives** which are provided on the Hornsea Four website in the Documents Library at:

1.1.1.4 https://hornseaprojects.co.uk/hornsea-project-four/documents-library/formal-consultation

1.1.1.5 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.

1.1.1.6 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..

1.1.1.7 The Applicant is submitting an application for a DCO to the Planning Inspectorate (PINS), supported by a range of plans and documents including an ES which sets out the results of

the EIA on the proposed offshore wind farm and its associated infrastructure, and an Annex to the EIA which assesses the environmental impact associated with the implementation of the proposed Compensation Measures, which are set out in this Compensation Project Description.

1.1.1.8 The Applicant is also submitting a RIAA which sets out the information necessary for the competent authority to undertake a Habitats Regulations Assessment (HRA) to determine if there is any Adverse Effect on Integrity (AEoI) on the national site network as a result of the development of the Hornsea Four offshore wind farm and its associated infrastructure. A separate HRA Screening exercise has been complete for the implementation of the Compensation Measures as presented in **Volume B2, Annex 2.2**.

1.2 The Derogation Provisions of the Habitats Regulations

1.2.1.1 The Habitat Regulations transposed into UK law the requirements of the Habitats Directive. Although the UK left the European Union (EU) on 31 January 2020, the Habitats Directive provides the legislative backdrop to the Habitats Regulations. The Habitats Directive seeks to conserve particular natural habitats and wild species across the EU by, amongst other measures, establishing a network of sites ("European sites") which together form the "National Site Network." The aim is to ensure the long-term survival of viable populations of Europe's most valuable and threatened species and habitats, to maintain and promote biodiversity.

1.2.1.2 The Habitats Directive acknowledges that the imperative of some plans and projects can outweigh the possible harm to a European site if that harm can be adequately compensated. The Directive provides a derogation under Article 6(4) that allows projects that may have an AEoI to be consented. In such a scenario, a derogation could only be provided under Article 6(4) if three tests are met in a sequential order:

i. There are no feasible alternative solutions to the project;
ii. There are "imperative reasons of overriding public interest" (IROPI) for the project to proceed; and
iii. Compensatory measures are secured that ensure that the overall coherence of the network of European sites is maintained.

1.2.1.3 The derogation tests thereby underpin a three-step process, which are hereafter referred to as the "HRA Derogation Provisions".

1.2.1.4 The Habitats Regulations do not define what is meant by or may comprise "compensatory measures" or when they must be delivered. There is also no definition of the "overall coherence of the National Site Network". In principle, both are broad concepts. The limited case law on compensation confirms only:

- Compensation is distinct from mitigation (i.e., measures which prevent, avoid or reduce the harm to the integrity of the affected European site)[1].
- Compensation can be delivered inside or outside a European site[2].

1.2.1.5 As there is no binding EU or UK case law that fixes the precise parameters of or timing for delivery of compensation, there is a degree of flexibility and it will be a matter of judgement for the Secretary of State (SoS) to determine what is "necessary" by way of compensation, acting reasonably and proportionately.

1.2.1.6 The Applicant firmly maintains the position that in respect of the designated sites, that there would be no AEoI as a result of the project alone and in-combination with other plans and projects and an AEoI can be ruled out beyond reasonable scientific doubt. The offshore wind farm and associated infrastructure RIAA will be submitted with the DCO application and will set out the in detail the assessment and conclusion of no AEoI.

1.2.1.7 Nonetheless, in light of the SoS's decision letters for recent windfarm applications (e.g. Hornsea Three and Norfolk Vanguard) that future projects should be mindful to ensure consideration of the need for derogation, including possible in-principle compensation measures are presented for consideration during the Examination of DCO application.

1.3 Development of Compensation Measures

1.3.1.1 The Applicant recognises the importance of engaging with the relevant stakeholders with respect to derogation and developing any potential compensation measures, as their knowledge is important. The Applicant has therefore sought to engage openly and transparently with the key stakeholders.

1.3.1.2 Consultation on the HRA Derogation Provisions has been ongoing in the latter stages of the pre-application stage during the course of a series of online workshops (employed during the COVID-19 pandemic to substitute meetings in-person). The Evidence Plan Process has been followed during the development of the derogation case and included a number of relevant authorities and stakeholders.

1.3.1.3 Throughout the Consultation period, the Applicant has sought the advice of key stakeholders and kept them updated on project developments. The online workshops were attended variably by Natural England, the Marine Management Organisation (MMO), the Department for Environment, Food and Rural Affairs (Defra), the Joint Nature Conservation Committee (JNCC), The Wildlife Trust (TWT), Royal Society for the Protection of Birds (RSPB), National Federation of Fishermen's Organisations (NFFO) the Planning Inspectorate (PINS),

[1] Case C-521/12 Briels and Others, paragraphs 38 – 39.
[2] Case C-521/12 Briels and Others, paragraphs 38 – 39

East Riding of Yorkshire Council (ERYC) and The Crown Estate (TCE). Detail of consultation activity undertaken will be submitted with the DCO application in the Record of Consultation.

1.3.1.4 The Compensation Measures outlined herein could be implemented should the SoS conclude AEoI on any of the qualifying features of FFC SPA.

1.4 Compensation measures

1.4.1.1 This EIA Project Description Annex describes the Compensation Measures that could be implemented to compensate for potential impacts upon ornithological features of FFC SPA. In summary, the potential Compensation Measures proposed, sub-options, locations, location ID and species being compensated are set out Table 1. It is anticipated that for guillemot and razorbill a package of measures could be required, rather than a single compensation measure. Compensation Measure Areas of Search are presented in the accompanying Location Plan (see **Figure 1**).

Table 1: Compensation Measures, sub-options, locations, location ID and species being compensated.

Compensation Measure	Option	Location	Location ID	Kittiwake	Gannet	Guillemot	Razorbill
Offshore nesting	New	southern North Sea	A1				
Offshore nesting	Repurposed	southern North Sea	A1				
Onshore nesting	New	Cayton Bay to Newbiggin by the Sea	B1				
		Suffolk Coast	B2				
Bycatch		Thames Estuary	C1				
		South coast of England: Broadstairs to Plymouth	C2				
Predator eradication		Isles of Scilly	D1				
		Rathlin Island, Moyle, Northern Ireland	D2				
		Torquay, Devon	D3				
		Guernsey and Aldernery	D4				
Fish habitat enhancement	Seagrass	Rathlin Island, Moyle, Northern Ireland	E1				
	Seagrass	Isles of Scilly	E2				
	Seagrass	Celtic Sea, Wales	E3				
	Seagrass	Plymouth Sound to Helford River	E4				
	Seagrass	Solent	E5				
	Seagrass	Essex Estuaries	E6				

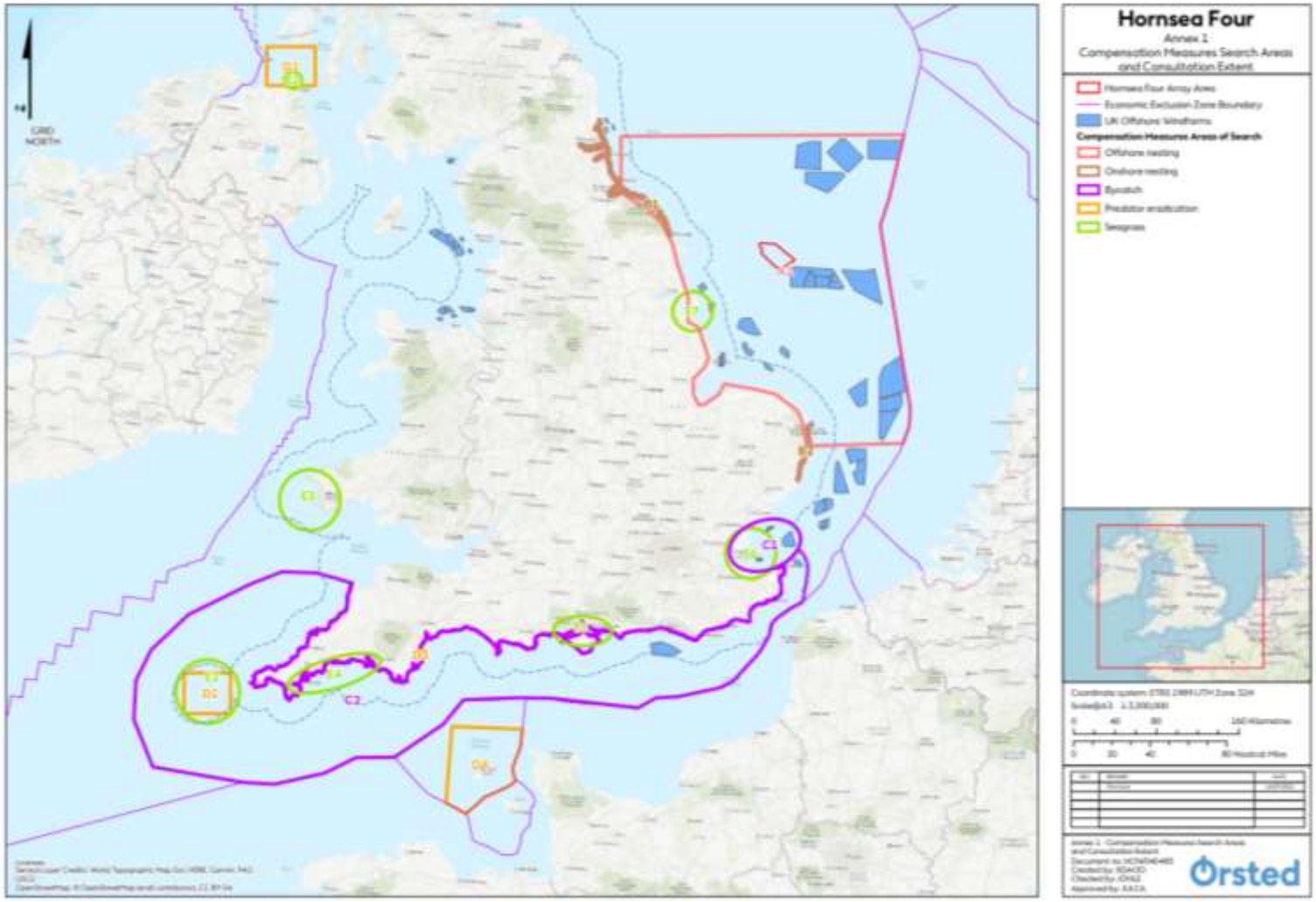

Figure 1: Compensation Search Areas

1.5 Programme

1.5.1.1 The high-level programme presented below is applicable to the implementation and delivery of all compensation measures.

- Anticipated Hornsea Four DCO Granted – Q1 2023
- Compensation implementation licencing – 2022/24
- Compensation Implementation – 2023/24
- Offshore Construction of Hornsea Four Offshore Wind Farm – 2027/28

1.6 Decommissioning

1.6.1.1 The requirement for, and the exact nature of decommissioning the offshore and onshore nesting structures, will be determined in consultation with the relevant authorities towards the end of the 35-year operational life of Hornsea Four. The Applicant will design the structures for a design life equal to that of the windfarm (i.e. 35 years plus 4 years to establish the compensation measures, pre-wind farm operation. Therefore, the lifetime of the structure is approximately 39 years). In the final few years of wind farm operation, the Applicant will commence inspections and surveys of the bird nesting structures to determine if an extension of the lifetime is possible.

1.6.1.2 It is currently anticipated that the predator eradication and bycatch measures implementation will result in new management practices which shall continue for the lifetime of Hornsea Four. Fish habitat enhancement (seagrass) compensation measure sites will be left in perpetuity.

2 Fish Habitat Enhancement

2.1 Introduction and Background

2.1.1.1 Fish habitat enhancement seeks to improve vital habitats for fish species such as those that provide spawning or nursery grounds to increase the productivity of fish species. Marine habitats that support fish populations such as seagrass, biogenic reef and mudflats have been considered for restoration in the UK to increase biodiversity (ABPmer, 2017; MMO, 2019). There is substantial evidence that these types of structured habitats enhance the density, growth, and survival of juvenile fishes and invertebrates (Lefcheck et al., 2019).

2.1.1.2 Seagrass meadows are amongst the most productive marine habitats in the U.K. Seagrass provides rich nursery habitat for a fifth of the world's biggest fishing species including pollock, herring and whiting, meaning their restoration can improve prey availability (Project Seagrass, 2021). Seagrass meadows provide shelter and food for juvenile fish (**Figure 2**), stabilise the sediment, reduce erosion, improve water quality, absorb excess nutrients and improve nutrient cycling, produce oxygen and store significant amounts of carbon.

Figure 2: Seagrass providing shelter for fish (copyright R.Unsworth).

2.1.1.3 While seabirds such as kittiwake, guillemot and razorbill often feed miles away from any seagrass, the species that they prey on, such as Gadoids and Clupeids, often utilise seagrass as nursery habitats (Bertelli and Unsworth, 2014; Lefcheck et al., 2019; Lilley and Unsworth, 2014; McDevitt-Irwin et al., 2016). At ocean basin scales seagrass is incredibly important in supporting fish stocks far from land with 20% of the worlds biggest fisheries supported by seagrass meadows through the provision of a nursery function to juvenile fish (Unsworth et al. 2019b). A high abundance of juvenile herring were found in seagrass in studies that took place in the United Kingdom, Denmark and the Baltic Sea (Bertelli and Unsworth, 2014; Polte and Asmus, 2006; Rönnbäck et al., 2007). Where seagrass meadows decline, there is evidence that this has negative effects on pelagic fish stocks (Kritzer et al. 2016; Seitz et al. 2013). This in turn, may impact the success of the species that feed on them.

2.2 The importance of seagrass

2.2.1.1 In England, seagrass is protected as an Annex 1 feature under the EU Habitats Directive, protected in designated Special Areas of Conservation and as a feature of Sites of Special Scientific Interest (SSSIs). Seagrass beds are also listed as Features of Conservation Interest (FOCI) in Marine Conservation Zones (MCZs). Seagrass beds (Z. marina and Z. noltei) are listed as a Priority Habitat derived from Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006.

2.2.1.2 Seagrass meadows are one of the world's most threatened ecosystems and are rapidly declining (Waycott et al., 2009). Factors affecting seagrass meadows and contributing to the decline include wasting disease, pollution and physical disturbance. In the UK, seagrass loss has been catastrophic and is estimated to have declined by 85% since the 1920s (Hiscock et al., 2005, Unsworth et al., 2019) and total UK losses could be as high as 92% (Green et al., 2021). Of the 155 estuaries in Britain, only 20 estuaries support seagrass and many are in poor condition and facing continued decline (Jones and Unsworth, 2016; Unsworth et al., 2017a,b; Unsworth et al., 2019). It is estimated that 39% of seagrass in the UK has been lost since the 1980's (Green et al., 2021). In the context of seabirds in the North

Sea there is very good evidence that seagrass has mostly disappeared from the coastline between Lindisfarne in the NE and Scolt head in Norfolk, a gap in straight line distance of almost 350km. Seabirds in that area no longer have access to resources within seagrass or supported by seagrass, with seagrass formerly in the Humber, the Tyne, the Tees and the Wash all but gone (Green et al. 2021; Unsworth, 2021).

2.2.1.3 The recognition of the importance and threats to seagrass has led to a number of trials around the UK and globally. Research has come a long way since the early trials in the 1970's in East Anglia which were unsuccessful. With the knowledge of the requirements for seagrass, restoration has been successful in many plantings and meadows have often come to perform much as naturally propagated meadows (Fonseca et al. 1985; Fonseca et al. 1996). In the UK researchers are seeing success from restoration trials planted in 2018 and will soon see the results of pilot projects deployed in 2020 and 2021 (Unsworth, 2021).

2.2.1.4 Through the Applicants work on the Environmental Impact Assessment and Habitats Regulations Assessment, the Applicant has been exploring opportunities to restore seagrass to support a range of ecosystems services and associated research, as a potential compensation measure. The Applicant recognises the importance of seagrass as a measure that can provide resilience to other compensation measures such as predator eradication, habitat management, bycatch mitigation and provision of artificial nesting. The Applicant proposes to provide a package of measures that will support the seabird populations such as kittiwake, guillemot and razorbill locally and in the North Sea. The measures will be designed to seek opportunities to be spatially co-located to maximise the benefits of the measures and located to ensure the overall coherence of the network is maintained. The Applicant is exploring a number of different fish habitats for enhancement such as mudflats, saltmarsh and reef. Recognising the importance of seagrass to fish populations and seabirds we are currently focusing on the opportunities for potential seagrass restoration projects.

2.3 Seagrass Restoration Projects

2.3.1.1 Seagrass restoration projects have been undertaken for over 50 years (MMO, 2019). For example, in Chesapeake Bay in the US, 3000 hectares of seagrass have been restored since the first survey in 1984 from once lifeless habitats, with rapid recovery of their ecosystem services now being observed (Orth et al. 2020). The restored seagrass meadows in Chesapeake Bay have recorded rapidly increasing ecosystem service provision from maturing restored seagrass meadows that have become indistinguishable from natural meadows (Orth et al. 2020).

2.3.1.2 In recent years a number of seagrass restoration projects have been undertaken in the UK. Project Seagrass and Swansea University led the UK's first major restoration project in Dale in West Wales. Although many aspects of this project have resulted in learning lessons, the overall project is considered a resounding success. In 2013, Swansea University commenced a programme of restoration work, studies on laboratory grown plants, transplantations and the movement of 'seagrass sods' were conducted alongside studies using seeds. This led to a range of trials utilising seagrass seeds planted in small hessian bags, a method that to date has been very successful in further studies in West Wales (Unsworth et al. 2019). The use of hessian seed bags helps to overcome the negative feedbacks caused by Green Shore crabs, unstable sediments and tidal loss of seeds (Maxwell et al. 2017). In 2020, over a million seagrass seeds were planted into Dale Bay in West Wales using the hessian seed bag method, over the coming 12 months and years these are expected to germinate and lead the development of the UK's first major seagrass restoration planting.

2.3.1.3 Seagrass meadows in the Humber Estuary have declined dramatically since the 1930's (Philip, 1936). The Humber Estuary is an important fish spawning area for sandeel, lemon and dover sole and important nursery area for plaice, herring, flounder and sprat (Rogers et al., 1998). Many of these species are prey for seabirds in the North Sea including kittiwake, guillemot and razorbill. Organisations are undertaking research and trials to expand the remaining 20ha of seagrass at Spurn Point Nature Reserve. Yorkshire Wildlife Trust are undertaking trials to discover the optimal conditions for gathering and germinating seagrass seeds (Yorkshire Wildlife Trust, 2021).

2.3.1.4 In Plymouth Sound and the Solent, the largest restoration project began in April 2021, a partnership project led by Ocean Conservation Trust (OCT) and involving Natural England, and numerous other stakeholders and volunteers (OCT, 2021). The project aims to plant seagrass bags across a total of eight hectares of seagrass meadows – four hectares in Plymouth Sound and four hectares in the Solent Maritime Special Area of Conservation. By planting seagrass, the project hopes to create more seagrass meadows which provide homes for juvenile fish and protected creatures like seahorses and stalked jellyfish (OCT, 2021).

2.3.1.5 The Applicant is exploring opportunities to expand existing seagrass restoration projects that are already underway and opportunities to create new projects with the academic community that could potentially form a resilience compensation measure, these broad locations are illustrated in **Figure 1**.

2.4 Seagrass Restoration Techniques

2.4.1.1 Seagrass restoration has been formally conducted for over 50 years and the means of doing this can principally be split into two major techniques:

- replanting; and
- reseeding.

2.4.1.2 Both techniques have their relative merits and have exhibited varying levels of success. Reseeding and replanting techniques have sometimes been used together. Using seeds possibly in conjunction with adult plants, may in some instances prove more effective (van Katwijk et al. 2016). A broad overview of the literature illustrates that although a lot is now known about seagrass restoration, there are research gaps and as a result the success rate of restoration projects can vary, demonstrating that it is vital that studies are undertaken to assess the feasibility and site selection and ensure the efficacy of the measure (Unsworth & Butterworth, 2021).

2.4.1.3 The use of reseeding generally relates to the collection and targeted redistribution (and sometimes processing) of wild seed. Adult shoot replanting normally involves harvesting plants from an existing meadow and transplanting them to the restoration site. The reproductive fronds of wild seed is collected by hand by SCUBA divers. The seeds collected by recent projects have obtained permits/consent from Natural England and Natural Resources Wales. Recent reports from the Environment Agency highlight the need for seagrass restoration to increasingly depend upon nursery grown propagules.

2.4.1.4 In most cases, shoot planting involves some means of anchoring the shoots to the bottom until the roots can take hold (root into the bottom). Replanting may use either weighted and anchored hessian sacks or mechanistic approaches, similar to tree planting, to plant various sizes and ages of seagrass plants into existing areas of seagrass, with the later technique favoured for areas of intertidal seagrass. Planting of seedlings may also be undertaken by divers who are transported to the site by boat. Seeds can also be directly deployed from the boat and often hessian bags are used to help anchor the seeds in place during germination. It is expected that up to two vessels would be required for the seagrass restoration at each location.

2.4.1.5 Seagrass restoration requires consideration of a range of factors necessary to make it a success. A recent review of the success of restoration projects globally found that success relates to the severity of the habitat degradation (van Katwijk et al. 2016). Seeds, adult plants and sods are not significantly different, although seedlings show lower success rates. A short distance to the donor site is also related to success.

2.4.1.6 Some seagrass restoration projects particularly the trials of small/medium sized projects have funding secured. The Applicant will look to fund additional areas for seagrass restoration that do not currently have funding secured and therefore provide additional benefit rather than projects that are part of normal practice and site/habitat management of the designated sites. Evidence gathering by the Applicant is ongoing and discussions with stakeholders on restoration projects and techniques is continuing. However, currently all types of restoration methods are being considered and may be combined using the best techniques at the time of restoration for the greatest success.

2.5 Location

2.5.1.1 Exploration of potential broad areas for seagrass restoration is ongoing. The main areas that are being considered consistently support all of the target seabird species and therefore provide options for seagrass restoration as well as supporting other compensation measures.

2.5.1.2 From April to July (breeding season), both guillemot and razorbill are located tightly around their colonies (around the coasts of the UK except for the Humber to the Isle of Wight). Outside of the breeding season, both species move further offshore, then start moving south. By December both species are located offshore around all UK coasts. As seabird distributions change throughout the year, the composition of their prey can also change, for example guillemot have a more varied diet in winter (Furness and Tasker, 2000). It will therefore be important to evaluate temporal variations when undertaking site selection analysis for the purpose of planning compensation measure locations.

2.5.1.3 Potential existing seagrass meadows located within proximity to the primary razorbill and guillemot compensation measures i.e. bycatch and predator eradication, with reported connectivity with the wider site network and the North Sea populations include the Solent, Channel Islands, Cornwall, Isles of Scilly, Essex Estuaries, Rathlin Island and Humber Estuary (see **Figure 1**). All of these locations are being considered for potential feasibility trails and future implementation.

2.6 Implementation, operation, and monitoring

2.6.1.1 Prior to any field studies commencing, detailed feasibility studies will be undertaken to assess the physical parameters for seagrass to be restored and undertake further stakeholder engagement. The Applicant recognise the need for feasibility studies to consider site selection and methodology to increase the likelihood of a successful restoration programme and efficacy of the compensation measure. Factors that will be considered prior to restoration efforts being initiated to ensure the viability of seagrass restoration include looking for sites:

- being sheltered from wave action;
- with suitable topographical and hydromorphological conditions including sedimentation rates;
- sufficient nutrients and available light;
- good water quality; and
- avoid sites with activities that could cause significant physical disturbance.

2.6.1.2 Surveys may be required to establish the levels of activity at the potential locations. Planting seagrass at sites previously known to support seagrass and known to have appropriate conditions for seagrass would likely result in increased biodiversity and ecosystem service provision (Unsworth, 2021). Part of the site selection process will take evidence of previous seagrass locations as a key consideration (Green et al., 2021).

2.6.1.3 For a new restoration project, we may conduct physical surveys (e.g. particle size, depth, slope, light, temp, total suspended solids, redox layer) and biological surveys as well as habitat mapping at each site, these could involve the use of camera drops and diver surveys to assess the suitability of the potential locations. When undertaking site selection studies, we will examine the health and nutrient status of the closest seagrass meadows or patch.

2.6.1.4 It may be necessary, especially with the potential scale restoration, that a series of surveys will be needed to identify potential seagrass meadows for future seed collections. This will be conducted in consultation with Natural England and other stakeholders. When planning the restoration project, we will focus on facilitating natural recovery through alleviating recruitment limitation.

2.6.1.5 The Applicant will undertake studies to understand the most appropriate scale for any resilience measure and consider how to maximise the benefits of spatial overlap/proximity to the other compensation measures. We recognise the importance of encouraging long-term survival by promoting self-facilitation through implementation at a large-enough scale. We will ensure that significant contingency, which may include reseeding/replanting, is built into the measure to provide the necessary confidence that it will have sufficient resilience, offset the impact and efficacy as a compensation measure.

2.6.1.6 Engagement with statutory and non-statutory bodies and local stakeholders and landowners will be undertaken to share and discuss our ambitions, plans and to ensure the success of the measures. We will work with academics and organisations with experience of previous restoration projects in order to ensure that activities build on the outcomes of best practice and lessons learnt.

2.6.1.7 Following the site suitability surveys a site selection process (potentially using a decision matrix) will be used to select the optimal site(s) for restoration. Environmental baseline surveys of the site(s) will be undertaken so that change over time can be assessed accordingly. Restoration of the seagrass using replanting and/ or reseeding methods will be undertaken following the methodology devised through engagement with academics and stakeholders. A pilot trial planting scheme is likely to be undertaken particularly for any new restoration location. Following the feasibility trials to gather further evidence on the efficacy of the seagrass restoration, the sites and methods will be selected to take forward.

2.6.1.8 There are many restoration projects being considered by a number of organisations in the UK and it may be that a project has already undertaken the required site selection and trials but is looking for the resource to undertake a larger scale scheme. The Applicant will discuss these options with academics and stakeholders as it may be that a suitable project is already underway that The Applicant could contribute towards to enable or expand the restoration project. Implementation of the planned compensation measure will begin following determination of the DCO application by the Secretary of State if required. All necessary permissions and consents will be obtained.

2.6.1.9 It is recognised that there are knowledge gaps on the specific linkages between seagrass in the UK and non-grazing seabirds and the level of the role of seagrass supporting forage fish for seabirds such as razorbill, guillemot and kittiwake. Whilst the broad understanding of the links between seagrass meadows and fisheries are well understood (Kritzer et al. 2016; Unsworth et al. 2019b), we still have limited evidence for this role at a UK level, with most data collected from only a handful of sites (Bertelli and Unsworth 2014; Peters et al. 2014). Understanding about temporal and spatial variability is particularly lacking (Unsworth & Butterworth, 2021). Whilst we know that forage fish species clupeids, gadoids and sand eels all utilise UK seagrass meadows at periods of the life cycle the nature of this role hasn't been quantified (Unsworth & Butterworth, 2021).

2.6.1.10 A key component of the fish habitat enhancement compensation measure will be research, to gather evidence to contribute towards filling these knowledge gaps. We have identified a number of initial potential research projects (in addition to feasibility studies) that the research could cover including:

- Foraging seagrass habitat study for seabirds including species counts, behavioural observations and habitat mapping;
- Fish surveys within seagrass meadows using seine and/or fyke netting;
- Further seabird diet studies; and
- Migratory fish tagging to understand fish movements.
- These potential research topics will be explored in greater detail and a research programme will be devised to support of the measures.

2.6.1.11 Hornsea Four is expected to operate for 35 years following construction. Monitoring of restoration will be essential to demonstrate the efficacy of the compensation measure and if required, the seagrass meadow would be monitored throughout the operational lifespan of the Hornsea Four. The exact method of monitoring will be decided based upon further evidence gathering and discussion with restoration experts and stakeholders. A Monitoring programme will be developed and at key stages the results of the restoration will be shared to improve the knowledge and evidence for seagrass restoration.

2.6.1.12 Adaptive management is an iterative process which combines management measures and subsequent monitoring with the aim of improving effectiveness whilst also updating knowledge and improving decision making over time. Adaptive management will be an important component of the compensation measure and will be used as a method to address unforeseen issues or deviations from expected time scales (i.e. additional infill planting required).

2.7 Summary of Fish Habitat Enhancement Compensation Measure

2.7.1.1 Fish habitat enhancement and in particular seagrass restoration is considered as a compensation measure to support the resilience of the other compensation measures to form a package of measures. In-combination with other kittiwake, razorbill and guillemot measures, predator eradication will be able to deliver the required level of compensation for Hornsea Four. A detailed evidence report, and roadmap will be submitted with the DCO application to demonstrate the potential compensation deliverable by the fish habitat enhancement both alone and combined with the other primary compensation measures. The evidence report will include a summary of the supporting evidence for fish habitat enhancement and the roadmap will outline the further steps that will be undertaken from submission to secure this compensation measure. The package of compensation measures is considered effective, feasible and securable measures that can be implemented prior to the impact occurring and sustainable for the life-time of the project. In designing this compensation measure the Applicant has consulted and worked with academics, Natural England, JNCC, the RSPB, The Wildlife Trust, other statutory bodies and other relevant stakeholders to ensure this compensation measure is both robust and deliverable.

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3.1 Introduction

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