# FIVE ESTUARIES OFFSHORE WIND FARM

## ENVIRONMENTAL STATEMENT

## VOLUME 6, PART 2, CHAPTER 6: FISH AND SHELLFISH ECOLOGY

| | |
|---|---|
| Application Reference | EN010115 |
| Application Document Number | 6.2.6 |
| Revision | A |
| APFP Regulation | 5(2)(a) |
| Date | March 2024 |

| | |
|---|---|
| Project | Five Estuaries Offshore Wind Farm |
| Sub-Project or Package | Environmental Statement |
| Document Title | Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology |
| Application Document Number | 6.2.6 |
| Revision | A |
| APFP Regulation | 5(2)(a) |
| Document Reference | 005024201-01 |



| Revision | Date | Status/Reason for Issue | Originator | Checked | Approved |
|---|---|---|---|---|---|
| A | Mar-24 | ES | GoBe | GoBe | VE OWFL |

CONTENTS

6 Fish and Shellfish Ecology .......... 13
6.1 Introduction .......... 13
6.2 Statutory and policy context .......... 13
6.3 Consultation .......... 31
6.4 Scope and methodology .......... 105
Scope of the assessment .......... 105
Study area .......... 106
Data sources .......... 107
Assessment Methodology .......... 113
6.5 Assessment criteria and assignment of significance .......... 113
Magnitude of impact .......... 113
Sensitivities of the receptors .......... 114
Significance of potential effects .......... 116
6.6 Uncertainty and technical difficulties encountered .......... 116
6.7 Existing environment .......... 119
Overview .......... 119
Fish and shellfish assemblage .......... 119
Spawning and nursery grounds .......... 119
Species of commercial importance .......... 138
Migratory species .......... 138
Elasmobranchs .......... 138
Species of conservation importance .......... 139
Valued ecological receptors .......... 142
Evolution of the baseline .......... 142
6.8 Key parameters for assessment .......... 145
6.9 Mitigation .......... 163
6.10 Additional mitigation .......... 164
6.11 Environmental assessment: construction .......... 165
Impact 1: Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration .......... 165
Impact 2: Temporary increase in SSC and sediment deposition .......... 242

Impact 3: Direct and indirect seabed disturbances leading to the release of sediment contaminants ........................................................................................................255
Impact 4: Impacts on fishing pressure due to displacement ........................................260
Impact 5: Direct damage (e.g. crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities ......................................261
Impact 6: Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors ....................................................................268
Impact 7: Temporary habitat loss/disturbance from construction operations including foundation installation and cable laying operations ....................................................270
6.12 Environmental assessment: operational hhase ...............................................277
Impact 8: Underwater noise as a result of operational WTGs and maintenance vessel traffic resulting in potential effects on fish and shellfish receptors. ..............................277
Impact 9: Temporary increase in SSC and deposition arising from operation and maintenance activities ..............................................................................................279
Impact 10: Impacts on fishing pressure due to displacement .......................................281
Impact 11: Long-term or permanent loss of habitat due to the presence of WTGs foundations, scour protection and cable protection ....................................................283
Impact 12: Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection.....................291
Impact 13: EMF effects arising from cables during operational phase ..........................297
Impact 14: Direct damage (e.g. crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from Operation and Maintenance activities ................300
Impact 15: Accidental pollution events during the operation and maintenance phase resulting in potential effects on fish and shellfish receptors.........................................301
Impact 16: Temporary habitat loss/disturbance ...........................................................303
6.13 Environmental assessment: decommissioning phase ............................................304
Impact 17: Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration ...........................................................................................................304
Impact 18: Temporary increase in SSC and sediment deposition .................................305
Impact 19: Direct and indirect seabed disturbance leading to the release of sediment contaminants .................................................................................................................305
Impact 20: Impacts on fishing pressure due to displacement .......................................306
Impact 21: Direct damage (e.g. crushing) and disturbance to mobile and demersal fish and shellfish species arising from decommissioning activities ......................................306
Impact 22: Accidental pollution events during the decommissioing phase resulting in potential effects on fish and shellfish receptors ...........................................................307

Impact 23: Temporary habitat loss/disturbance ....................................................307
6.14 Environmental Assessment: Cumulative Effects ............................................307
Impact 24: Cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration.......................................................................................317
Impact 25: Cumulative temporary increase in SSC and sediment deposition ................321
Impact 26: Cumulative temporary habitat loss ...........................................................323
Impact 27: Cumulative long term or permanent habitat loss .......................................325
6.15 Climate Change .......................................................................................326
Effect of climate change on the local environment .....................................................326
Effect of climate change and the project on the local environment...............................327
6.16 Inter-relationships....................................................................................327
6.17 Transboundary effects...............................................................................327
6.18 Summary of effects ..................................................................................328
6.19 References..............................................................................................337

## TABLES

Table 6.1: Legislation and policy context. ..........................................................15
Table 6.2: Summary of consultation relating to Fish and Shellfish Ecology.........................32
Table 6.3: Data sources used to inform fish and shellfish baseline characterisation and assessment .....................................................................................................109
Table 6.4: Impact magnitude definitions. ............................................................113
Table 6.5: Sensitivity/importance of the receptor .....................................................115
Table 6.6: Matrix to determine effect significance. ......................................................116
Table 6.7: Summary of fish spawning and nursery habitats within the VE fish and shellfish study area from data presented in Coull *et al*., 1998 and Ellis *et al*., 2010; 2012. ............124
Table 6.8: Summary of spawning timings in the Southern North Sea for fish species known to have spawning habitats in the VE study area (Light blue indicates spawning period, dark blue indicates peak spawning period)...........................................................129
Table 6.9: Fish and Shellfish VERs. ......................................................................142
Table 6.10: Maximum design scenario for VE alone. ...................................................146
Table 6.11: Mitigation relating to fish and shellfish ecology. ..........................................163
Table 6.12: Additional mitigation relating to fish and shellfish ecology. ............................165
Table 6.13: Scope of underwater noise assessment .....................................................166
Table 6.14: MDS for foundations installation in the array areas. ......................................169
Table 6.15: Hearing categories of fish receptors (Popper *et al*., 2014).............................172
Table 6.16: Impact Threshold Criteria from Popper *et al*., (2014)....................................173

Table 6.17: Noise modelling results for injury ranges for fleeing and stationary receptors for piling at single locations ....174
Table 6.18 Noise modelling results for injury ranges for fleeing and stationary receptors for sequential piling at multiple locations ....177
Table 6.19 Noise modelling results for injury ranges for fleeing and stationary receptors (concurrent piling at multiple locations)....180
Table 6.20: Group 1 VERs Sensitivity. ....183
Table 6.21: Group 2 VERs Sensitivity. ....187
Table 6.22: Group 3 VERs Sensitivity. ....188
Table 6.23: Summary of behavioural noise response thresholds identified in literature ....216
Table 6.24: Qualitative behavioural criteria (Popper et al, 2014) ....217
Table 6.25: MDS for sheet pile installation at landfall. ....224
Table 6.26: Noise modelling results for injury ranges for fleeing and stationary receptors for sheet piling. ....225
Table 6.27: VERs Sensitivity to increased SSC and deposition ....245
Table 6.28: VERs Sensitivity to increased SSC and deposition. ....249
Table 6.29: Sensitivity of VERs to the release of sediment contaminants from works within the array areas. ....256
Table 6.30: Sensitivity of VERs to the release of sediment contaminants from works within the offshore ECC. ....258
Table 6.31: Sensitivity of VERs to direct damage and disturbance. ....262
Table 6.32:Sensitivity of VERs to direct damage and disturbance in the offshore ECC ....265
Table 6.33: Sensitivity of VERs to temporary habitat loss. ....271
Table 6.34: Sensitivity of VERs to temporary habitat loss within the offshore ECC....274
Table 6.35: Sensitivity of VERs to long-term or permanent habitat loss. ....284
Table 6.36: Sensitivity of VERs to long-term or permanent habitat loss. ....287
Table 6.37: Sensitivity of VERs to increased hard substrate and structural complexity.....292
Table 6.38: Sensitivity of VERs to increased hard substrate and structural complexity within the offshore ECC. ....295
Table 6.39: Description of Tiers of other developments considered for cumulative effect assessment. ....308
Table 6.40: Projects considered within the fish and shellfish ecology cumulative effect assessment. ....311
Table 6.41: Impacts excluded from the CEA ....313
Table 6.42: Cumulative MDS. ....315
Table 6.43: Cumulative piling durations for VE and other OWFs within a representative 100 km buffer of VE (where construction or decommissioning occurs concurrently). ....319
Table 6.44: Summary of effects on fish and shellfish receptors....329

## FIGURES


Figure 6.1 East Marine Plan Area....30
Figure 6.2 Fish and Shellfish Study Area....121
Figure 6.3 Mackerel, plaice, whiting and sandeel spawning grounds relative to the VE OWF ....122
Figure 6.4 Sole, sprat, cod, horse mackerel and lemon sole spawning grounds relative to the VE OWF. ....123
Figure 6.5 Herring Spawning and Nursery Grounds....132
Figure 6.6 Herring Spawning Grounds Relative to the Fish and Shellfish Study Area....133
Figure 6.7 Herring Spawning Potential Heat Map....134
Figure 6.8 Sandeel Spawning Grounds Relative to the Fish and Shellfish Study Area ....136
Figure 6.9 Sandeel Spawning Potential Heat Map ....137
Figure 6.10 Sea Bass Nursery Grounds....140
Figure 6.11. Designated Sites ....141
Figure 6.12 MDS Sequential pilling of pin pile foundations within the array areas of a single location (3,000KJ, stationary Receptor)....230
Figure 6.13 MDS alternate pilling of monopile foundations within the array areas at multiple locations (7,000KJ, stationary receptors)....231
Figure 6.14 MDS alternate pilling of monopile foundations within the array areas at multiple locations (7,000KJ, stationary receptors) within a 24 hour period ....232
Figure 6.15 MDS concurrent pilling of monopile foundations at multiple locations within the array areas (7,000KJ, stationary receptors)....233
Figure 6.16 MDS piling of a single monopile foundation at one location within the array areas (7,000 KJ, fleeing receptors)....234
Figure 6.17 MDS alternate piling of monopiles at multiple locations within the array areas (7,000KJ, fleeing receptor) ....235
Figure 6.18 MDS alternate piling of monopiles at multiple locations within the array areas (7,000KJ, fleeing receptor) within a 24 hour period ....236
Figure 6.19 MDS concurrent piling of monopile foundations at multiple locations within array areas (7,000KJ, fleeing receptors)....237
Figure 6.20 MDS sequential piling of sheet piles within the landfall (300KJ, stationary receptors) ....238
Figure 6.21 MDS sequential piling of sheet piles within the landfall (300KJ, fleeing receptors) ....239
Figure 6.22 MDS piling of pin pile foundations, 5db increments (3,000 KJ, stationary receptors) ....240
Figure 6.23 MDS piling of monopile foundations, 5db increments (7,000 KJ, stationary receptors) ....241
Figure 6.24 Projects and plans screened into the fish and shellfish ecology cumulative assessment ....310

## GLOSSARY OF TERMS

| Term | Definition |
| --- | --- |
| Array areas | The areas where the wind turbines will be located |
| Array cables | Cables which connect the wind turbines to each other and to the offshore substation(s) |
| Cumulative effects | The combined effect of Five Estuaries Offshore Wind Farm (VE) 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 VE. |
| Design Envelope | A description of the range of possible elements that make up the Five Estuaries design options under consideration, as set out in detail in the project description. This envelope is used to define Five Estuaries 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 a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for Department for Energy Security and Net Zero (ESNZ). |
| Effect | Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria. |
| 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. |
| Export cables | Cables that transfer power from the offshore substation(s) or the converter station(s) to shore. |
| Export cable corridor (ECC) | The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Five Estuaries array area to the proposed substation areas, within which the export cables will be located. |
| Impact | An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial, resulting from the activities associated with the construction, operation and maintenance, or decommissioning of the project. |
| Interconnector cables | Cables that may be required to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, or |

| Term | Definition |
| --- | --- |
| | to connect to the offshore accommodation platforms in order to provide power for operation. |
| Maximum design scenario (MDS) | The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed. |
| Mitigation | Mitigation measures, or commitments, are commitments made by the project to reduce and/or eliminate the potential for significant effects to arise as a result of the project. |
| Offshore substation(s) | One or more offshore substations to convert the power to higher voltages and/or to HVDC and transmit this power to shore. |
| Planning Inspectorate (PINS) | The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs). |
| Report to Inform Appropriate Assessment | A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI) and compensatory measures. |
| Scour and cable protection | In order to prevent seabed scour around foundation structures and cables, cable protection may be placed on the seabed to protect from current and wave action. |
| Side Scan Sonar (SSS) | Side-imaging sonar used to create an image of the seafloor. |
| Single-beam and multi-beam echo sounders (SBES and MBES) | A type of sonar which transmits soundwaves, using the time taken between emission and return to establish a depth. This can be done using singular or multiple beams. |
| Subtidal | The region of shallow waters which are below the level of low tide. |
| Wind turbine | All of the components of a wind turbine, including the tower, nacelle, and rotor. |
| Wind turbine foundation | The wind turbines are attached to the seabed with a foundation structure typically fabricated from steel or concrete. |

## DEFINITION OF ACRONYMS

| Term | Definition |
|---|---|
| AoS | Area of Search |
| BGS | British Geological Society |
| BEIS | Business, Energy and Industrial Strategy |
| BNA | Bass Nursery Area |
| CBRA | Cable Burial Risk Assessment |
| CEA | Cumulative Effects Assessment |
| Cefas | Centre for Environment, Fisheries and Aquaculture |
| CIEEM | Chartered Institute of Ecology and Environmental Management |
| CSIP | Cable Specification and Installation Plan |
| dB | Decibel |
| DCO | Development Consent Order |
| DECC | Department for Energy and Climate Change |
| Defra | Department of Environmental Food and Rural Affairs |
| DOM | Dissolved Organic Matter |
| ECC | Export Cable Corridor |
| EA | Environment Agency |
| EEZ | Exclusive Economic Zone |
| EIA | Environmental Impact Assessment |
| EIFCA | Eastern Inshore Fisheries and Conservation Authority |
| EMF | Electromagnetic Fields |
| EMP | Environmental Monitoring Programme |
| ES | Environmental Statement |
| ESNZ | Department for Energy Security and Net Zero |
| EU | European Union |
| GBS | Gravity Base Structure |
| GES | Good Environmental Status |
| HDD | Horizontal Directional Drilling |
| HRA | Habitats Regulation Assessment |
| ICES | International Council for the Exploration of the Sea |
| IHLS | International Herring Larvae Survey |

| Term | Definition |
|---|---|
| IMO | International Maritime Organisation |
| INSS | Invasive Non-Native Species |
| JNCC | Joint Nature Conservation Committee |
| KEIFCA | Kent & Essex Inshore Fisheries and Conservation Authorities |
| kJ | Kilojoule |
| LSE | Likely Significant Effect |
| MALSF | Marine Aggregate Levy Sustainability Fund |
| MCA | Maritime and Coastguard Agency |
| MCAA | Marine and Coastal Access Act |
| MCZ | Marine Conservation Zones |
| MDS | Maximum Design Scenario |
| MHWS | Mean High Water Spring |
| MLWS | Mean Low Water Spring |
| MMO | Marine Management Organisation |
| MPCP | Marine Pollution Contingency Plan |
| MPI | Multi-Purpose Interconnector |
| MPS | Marine Policy Statement |
| MSFD | Marine Strategy Framework Directive |
| NE | Natural England |
| NERC | Natural Environment Research Council |
| NPS | National Policy Statement |
| NSIBTS | North Sea International Bottom Trawl Survey |
| OL | Order Limits |
| O&M | Operation & Maintenance |
| OSP | Offshore Substation Platform |
| OWF | Offshore Wind Farm |
| PEMP | Project Environmental Management Plan |
| PEIR | Preliminary Environmental Information Report |
| PEL | Probable Effect Levels |
| PINS | Planning Inspectorate |
| POL | Proposed Order Limits |

| Term | Definition |
|---|---|
| PSA | Particle size analysis |
| RIAA | Report to Inform Appropriate Assessment |
| RMS | Root Mean Square |
| SAC | Special Area of Conservation |
| SEL | Sound Exposure Level |
| SoS | Secretary of State |
| SPA | Special Protection Area |
| SPL | Sound Pressure Level |
| SPP | Scour Protection Plan |
| SQG | Small Quantity Generator |
| SSC | Suspended Sediment Concentration |
| SSSI | Special Scientific Interest |
| TTS | Temporary Threshold Shift |
| UXO | Unexploded Ordnance |
| WTG | Wind WTGs Generator |
| VE | Five Estuaries |
| VER | Valued Ecological Receptor |
| ZoI | Zone of Influence |

# 6 FISH AND SHELLFISH ECOLOGY

## 6.1 INTRODUCTION

6.1.1 GoBe Consultants Ltd have prepared this chapter in order to assess the potential effects of development (including construction, operation and maintenance (O&M) and decommissioning) associated with Five Estuaries (VE) Offshore Wind Farm (hereafter referred to as VE) on fish and shellfish receptors.

6.1.2 This chapter has been informed by the following Environmental Statement (ES) chapters:

- Volume 6, Part 2, Chapter 1: Offshore Project Description;
- Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
- Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality;
- Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology;
- Volume 6, Part 2, Chapter 8: Commercial Fisheries;
- Volume 6, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report;
- Volume 6, Annex 6.2: Underwater Noise Technical Report; and
- Volume 6, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey (IHLS) Data).

## 6.2 STATUTORY AND POLICY CONTEXT

6.2.1 This section identifies legislation and national and local policy of relevance to fish and shellfish ecology. The Marine Works (Environmental Impact Assessment) Regulations 2007 and the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (together referred to as 'the EIA Regulations') and the Planning Act 2008 are considered along with the legislation relevant to fish and shellfish ecology.

6.2.2 The following section provides information regarding the legislative context surrounding the assessment of potential effects in relation to fish and shellfish ecology. Full details of all policy and legislation relevant to the VE application are provided within Volume 6, Part 1, Chapter 2: Policy and Legislation. A summary of the current policy and legislation specifically relevant to fish and shellfish receptors is provided below. Five Estuaries Offshore Wind Farm Limited (hereafter the Applicant) has ensured that the assessment adheres to the relevant legislation.

6.2.3 In undertaking the assessment, the following policy and legislation has been considered:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;
- The Marine Works (Environmental Impact Assessment) Regulations 2007;
- The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979);

- EU Council Directive 92/ 43/ EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive')[1];
- The Conservation of Habitats and Species Regulations 2017 ;
- The Conservation of Offshore Marine Habitats and Species Regulations 2017;
- Marine and Coastal Access Act 2009;
- The Wildlife and Countryside Act 1981 (as amended); and
- East Inshore, East Offshore and South East Inshore Marine Plans (See Figure 6.1);
- Marine Strategy Framework Directive 2008.

6.2.4 Table 6.1 provides a summary of the key policy provisions of relevance to this assessment.

6.2.5 Guidance on the issues to be assessed for offshore renewable energy developments has been obtained through reference to:

- Overarching National Policy Statement (NPS) for Energy (NPS EN-1; DESNZ, 2023);
- National Policy Statement for Renewable Energy Infrastructure (NPS EN-3; DESNZ, 2023);
- National Policy Statement for Electricity Networks Infrastructure EN-5 (NPS EN-5; DESNZ, 2023);
- UK Marine Policy Statement (MPS; HM Government, 2011).
- The assessment of potential effects from underwater noise has been carried out utilising the widely used and recognised criteria by Popper *et al*., (2014).

[1] The Habitats Directive (Council Directive 92/43/EEC) and certain elements of the Wild Birds Directive (Directive 2009/147/EC) (known as the Nature Directives) were transposed into domestic law by the 2017 Regulations. Following the UK's exit from the EU the Regulations were updated by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 to reflect that the UK was no longer part of the EU. Any references to Natura 2000 in the 2017 Regulations and in guidance now refers to the new national site network.

**Table 6.1: Legislation and policy context.**

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| NPS EN-3 (DESNZ, 2023) | *Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs*<br>(Paragraph 2.8.101 of NPS EN-3). | Construction, operations and maintenance, and decommissioning phases of VE have been assessed in Sections 6.11, 6.12 and 6.13. |
| | *Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects.*<br>Paragraph 2.8.103 of NPS EN-3) | The assessment methodology includes the provision for assessment of both positive and negative effects (Section 6.4). |
| | *Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations/non-governmental organisations as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options should be undertaken.*<br>(Paragraph 2.8.104 of NPS EN-3). | Consultation with relevant statutory and non-statutory stakeholders has been carried out from the early stages of VE (see Section 6.3 for a summary of consultation undertaken with regard to fish and shellfish). |
| | *Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate.* | Relevant data collected as part of post-construction monitoring from other OWF developments within the defined study area (i.e., Gunfleet Sands OWF, Galloper OWF, Greater Gabbard OWF and London Array OWF) |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | (Paragraph 2.8.106 of NPS EN-3). | has informed the assessment of VE (see Sections 6.4 and 6.7). |
| | *There is the potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to impact fish communities, migration routes, spawning activities and nursery areas of particular species.*<br>(Paragraph 2.8.148 of NPS EN-3). | The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects inclusive of impacts from underwater noise presented within Sections 6.11 and 6.13. |
| | *"There are potential impacts associated with energy emissions into the environment (e.g. noise or EMF), as well as potential interaction with seabed sediments."* *(Paragraph 2.8.149 of NPS EN-3).* | The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects inclusive of impacts from underwater noise and EMF presented within Sections 6.11 and 6.13. |
| | *"The applicant should identify fish species that are the most likely receptors of impacts with respect to:*<br>*spawning grounds;*<br>*nursery grounds;*<br>*feeding grounds;*<br>*over-wintering areas for crustaceans;*<br>*migration routes ; and*<br>*protected sites.*<br>(Paragraph 2.8.150 of NPS EN-3). | The key receptors of impacts are listed in Section 6.7. Consideration has been given to receptors with regards to spawning grounds, nursery grounds, feeding grounds, over-wintering areas, migration routes and fish and shellfish features of protected sites, with those receptors of potential sensitivity to impacts from the development of VE assessed within Sections 6.11 and 6.12. |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *"Applicant assessments should identify the potential implications of underwater noise from construction and unexploded ordnance (UXO) including, where possible, implications of predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold shift (TTS) and disturbance and addressing both sound pressure and particle motion) and EMF on sensitive fish species."* (Paragraph 2.8.151 of NPS EN-3) | The potential for impacts from underwater noise, relating to both sound pressure and particle motion on sensitive fish and shellfish receptors are assessed in Sections 6.11 (Impact 1), 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). The potential for impacts from EMF on sensitive receptors is assessed in Section 6.12 (Impact 13). |
| | *"Offshore wind farms can have a negative impact on some fish stocks and fishing activity, and/or a positive impact on other fish stocks and/or other types of commercial fishing".* (Paragraph 2.8.156 of NPS EN-3). | The effects on fish and shellfish receptors of commercial importance have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. Potential impacts on fishing activity have been assessed in Volume 6, Part 2, Chapter 8: Commercial Fisheries. |
| | *"Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed."* (Paragraph 2.8.218 of NPS EN-3). | Mitigation relevant for the fish and shellfish ecology chapter is detailed in Sections 6.9 and 6.10. A seasonal piling restriction has been proposed to mitigate against impacts to spawning herring from underwater noise. This is summarised in Table 6.12. |
| | *"Should impacts be greater than those predicted, an adaptive management process may need to be implemented and additional mitigation required, to ensure that so far as possible the effects are brought back within the range of those predicted."* | The potential for effects on fish and shellfish receptors have been assessed in Sections 6.11, 6.12, 6.13 and 6.14 of this chapter. Where significant effects have been concluded, additional mitigations have been |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | (Paragraph 2.8.222 of NPS EN-3) | proposed. These measures are summarised in Table 6.12. |
| | *"EMF in the water column during operation, is in the form of electric and magnetic fields, which are reduced by use of armoured cables for interarray and export cables."*<br>(Paragraph 2.8.245 of NPS EN-3) | The potential for impacts from EMF on fish and shellfish receptors have been assessed in Section 6.12, Impact 13. |
| | *"Burial of the cable increases the physical distance between the maximum EMF intensity and sensitive species. However, what constitutes sufficient depth to reduce impact may depend on the geology of the seabed."*<br>(Paragraph 2.8.246 of NPS EN-3) | The potential for impacts from EMF on fish and shellfish receptors have been assessed in Section 6.12, Impact 13.<br>A detailed CBRA (within the CSIP) will be undertaken to enable informed judgements regarding burial depth as informed by the geology of the site (Table 6.11). Where burial depth cannot be achieved, cable armouring will be implemented (e.g., mattressing, rock placement etc), which will also provide physical distance between the maximum EMF intensity and sensitive species (Table 6.11). |
| | *"Construction of specific elements can also be timed to reduce impacts on spawning or migration. Underwater noise mitigation can also be used to prevent injury and death of fish species."*<br>(Paragraph 2.8.249 of NPS EN-3) | A seasonal piling restriction has been proposed to mitigate against impacts to spawning herring from underwater noise. This is summarised in Table 6.12. |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *The Secretary of State (SoS) should consider the effects of a proposed development on marine ecology and biodiversity, considering all relevant information made available by the applicant.* (Paragraph 2.8.302 of NPS EN-3). | The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects presented within in Sections 6.11, 6.12, 6.13 and 6.14 of this chapter. |
| | *The designation of an area as a protected site (including SACs, SPAs, and Ramsar sites, Marine Conservation Zones (MCZs) and Special Scientific Interest (SSSIs) does not necessarily restrict the construction or operation of offshore wind farms in or near that area. However, it may make consent for such construction more difficult to secure.* (Paragraph 2.8.304 of NPS EN-3). | Designated sites within the region have been identified in Section 6.7 as appropriate, as well as Volume 5, Report 6: Marine Conservation Zone Assessment. Any potential impacts to features of the sites have been assessed in in Sections 6.11, 6.12, 6.13 and 6.14 of this chapter. |
| | *The use of external cable protection has been suggested as a mitigation for EMF (by increasing the distance between fish species and individual cables). However, the Secretary of State should also consider any negative impacts from external cable protection on benthic habitats, and a balance between protection of various receptors must be made, with all mitigation and alternatives reviewed.* (Paragraph 2.8.310 of NPS EN-3). | The impacts of EMF on fish and shellfish receptors have been considered, with the assessment of effects presented within Section 6.12, Impact 13. The impacts of long-term habitat loss or permanent loss of habitat due to the presence of cable protection on fish and shellfish receptors and spawning substates have been assessed under Section 6.12, Impact 11. The potential for impacts from external cable protection on benthic and intertidal ecology have been assessed in Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology. |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| NPS EN-1 (DESNZ, 2023) | *Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance and will be protected accordingly. Those that are not, or those features of SSSIs not covered by an international designation should be given a high degree of protection. Most National Nature Reserves are notified as SSSIs.*<br>*Development on land within or outside a SSSI, and which is likely to have an adverse effect on it (either individually or in combination with other developments), should not normally be permitted. The only exception is where the benefits (including need) of the development in the location proposed clearly outweigh both its likely impact on the features of the site that make it of special scientific interest, and any broader impacts on the national network of SSSIs.*<br>(Paragraphs 5.4.7 and 5.4.8 of NPS EN-1). | Designated sites within the region have been identified in Section 6.7 as appropriate. No SSSIs have been identified within the ZoI of the project. |
| | *Marine Conservation Zones (MCZs) introduced under the Marine and Coastal Access Act (MCAA) 2009 are areas that have been designated for the purpose of conserving marine flora and fauna, marine habitat or features of geological or geomorphological interest. The protected feature or features and the conservation objectives for the MCZ are stated in the designation order for the MCZ. If a proposal is likely to have significant impacts on an MCZ, an MCZ Assessment* | The only MCZ identified within the ZoI of the project is the Blackwater, Crouch, Roach and Colne Estuary MCZ, this is detailed in Section 6.7 and presented in Figure 6.11. Any potential impacts to features of the site have been assessed in in Sections 6.11, 6.12, 6.13 and 6.14 of this chapter. |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *should be undertaken as per the requirements under section 126 of the Marine and Coastal Access Act, 2009. Government has recently designated the first three Highly Protected Marine Areas in England. These are designated as MCZs but with a higher conservation objective and with a single feature of the whole ecosystem within the site boundaries.* (Paragraph 5.4.9 of NPS EN-1) | |
| | *Many individual species receive statutory protection under a range of legislative provisions. Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales, as well as for their continued benefit for climate mitigation and adaptation and thereby requiring conservation action.* (Paragraph 5.4.16 of NPS EN-1) | All species receptors, including those of conservation importance are summarised in Section 6.7 and listed in Table 6.9. |
| | *Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats.* | The potential effects of VE have been assessed in regard to national and local sites designated for ecological or geological features of conservation importance (see Sections 6.11, 6.12, 6.13 and 6.14). Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites are also considered in the Habitats Regulations Assessment Screening Report and where relevant will be included in the Volume 5, Report 4: Report to Inform Appropriate Assessment (RIAA). |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Secretary of State consider thoroughly the potential effects of a proposed project.*<br>(Paragraphs 5.4.17 to 5.4.18 of NPS EN-1). | |
| | *Applicants should include appropriate avoidance, mitigation, compensation and enhancement measures as an integral part of the proposed development. In particular, the applicant should demonstrate that:*<br>> *during construction, they will seek to ensure that activities will be confined to the minimum areas required for the works*<br>> *the timing of construction has been planned to avoid or limit disturbance*<br>> *mitigations required as a result of legal protection of habitats or species will be complied with.*<br>(Paragraph 5.4.35 of NPS EN-1) | Mitigation relevant for the fish and shellfish ecology chapter, and proposed for implementation to the construction period, are summarised in Table 6.11. These include the development of, and adherence to, a CSIP post consent, which accords with the Outline CSIP (Volume 9, Report 12). The CSIP will set out appropriate cable burial depth in accordance with industry good practice, minimising the risk of cable exposure, and will ensure that cable crossings are appropriately designed to mitigate environmental effects.<br>A MMMP (Piling and UXO) will be developed in accordance with the Outline MMMP (Volume 9, Report 14.1: Outline MMMP – Piling and 14.2 Outline MMMP - UXO). This will include details of soft starts and ramp up procedures to be used during piling operations.<br>Further additional mitigation measures have been proposed to mitigate against potential impacts to spawning herring, these are summarised in Table 6.12, and include a seasonal piling to mitigate against |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | | impacts to spawning herring from underwater noise, and a sediment disposal restriction to mitigate against impacts to spawning herring from smothering effects from sediment deposition. |
| Marine Strategy Framework Directive (MSFD) | Descriptor 1 – *Biological diversity: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.* | The effects on biological diversity have been described and considered within the assessment for VE alone and the cumulative effects assessment (CEA) (Sections 6.11, 6.12, 6.13 and 6.14). |
| | Descriptor 2 – *"Non-indigenous species: non-indigenous species introduced by human activity are at levels that do not adversely alter the ecosystems".* | The potential for effects associated with non-indigenous species of fish and shellfish ecology that may be attributable to the VE project have been assessed in Section 6.12 (Impact 12). |
| | Descriptor 3 – *Commercial species: The population of commercial fish species is healthy*. | The effects on commercial fish and shellfish species have been described and considered within the assessment for VE alone and in the CEA (Sections 6.11, 6.12, 6.13 and 6.14). |
| | Descriptor 4 – *Elements of marine food web: All elements of marine food webs, to the extent they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity*. | The effects on fish and shellfish ecology, inclusive of the interlinkages with interdependent ecological receptors described in other chapters is integral within this chapter and the wider Environmental Statement with inter relationships detailed in Volume 6, Part 4, Chapter 3: Interrelationships and summarised in Section 6.16. |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | Descriptor 6 – *Sea floor integrity: Sea floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*. | The effects on fish and shellfish ecology, inclusive of any risk to ecological integrity, has been described and considered within the assessment for VE alone and in the CEA (Sections 6.11, 6.12, 6.13 and 6.14). |
| | Descriptor 8 – *Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects*. | The effects of contaminants on fish and shellfish and species have been assessed in Sections 6.11 (Impact 3) and 6.13 (Impact 19). |
| | Descriptor 9 – *Contaminants in seafood: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards*. | The effects of contaminants on fish and shellfish and species have been assessed in Sections 6.11 (Impact 3) and 6.13 (Impact 19). |
| | Descriptor 10 – *Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment*. | A PEMP in accordance with Volume 9, Report 18 Outline Project Environmental Management Plan will be produced prior to construction and followed to cover the construction and operational phases of VE. The PEMP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g., Marine Management Organisation (MMO), EA and Maritime and Coastguard Agency (MCA)). A Decommissioning Plan will be developed to cover the decommissioning phase. |
| | Descriptor 11 – *Energy incl. underwater noise: introduction of energy, including underwater noise, is at* | The effects of underwater noise on fish and shellfish have been assessed in Sections 6.11 (Impact 1), 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). |

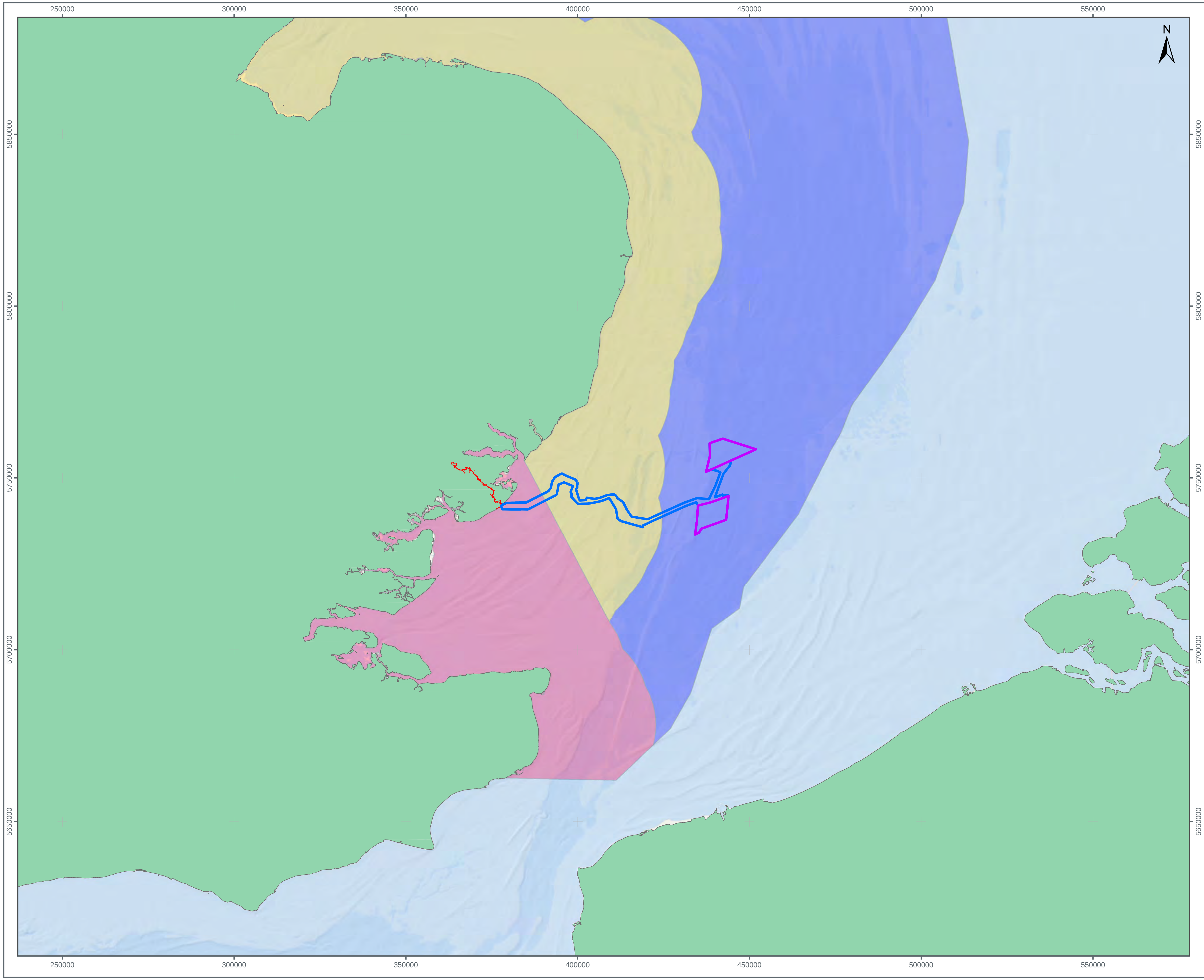
| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *levels that do not adversely affect the marine environment.* | |
| East Offshore Marine Plans | Policy ECO1: *Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation*. | Cumulative effects are considered within Section 6.14. |
| | Policy BIO1: *Appropriate weight should be attached to biodiversity, reflecting the need to protect biodiversity as a whole, taking account of the best available evidence including on habitats and species that are protected or of conservation concern in the East marine plans and adjacent areas (marine, terrestrial)*. | Due consideration to the baseline characterisation of the site has been given in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, which is informed by the best available evidence, inclusive of consideration of protected or conservation species. This is summarised in Section 6.7. Potential impacts on protected or conservation species have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. |
| | Policy FISH2: *Proposals should demonstrate, in order of preference:*<br>*a) that they will not have an adverse impact upon spawning and nursery areas and any associated habitat*<br>*b) how, if there are adverse impacts upon the spawning and nursery areas and any associated habitat, they will minimise them*<br>*c) how, if the adverse impacts cannot be minimised they will be mitigated* | Potential impacts on fish and shellfish receptors have been assessed in Sections 6.11, 6.12, 6.13 and 6.14, and mitigation detailed in Section 6.9 and 6.10. To summarise, prior to mitigation measures, significant effects for underwater noise and increased SSC and deposition for spawning herring have been concluded and appropriate mitigation has been proposed in Table 6.12. Aside from this, no other significant effects have been concluded for fish and shellfish receptors. |

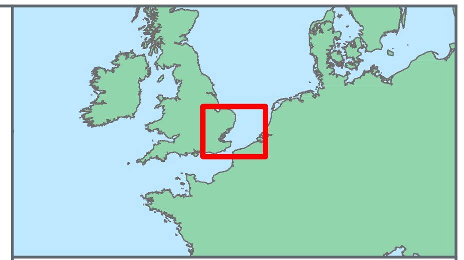
| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *d) the case for proceeding with their proposals if it is not possible to minimise or mitigate the adverse impacts.* | |
| | Policy MPA1: *Any impacts on the overall marine protected area (MPA) network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network*. | Designated nature conservation sites within the VE study area have been described in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. Potential impacts to fish and shellfish features of designated sites have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. Impacts to marine conservation zones have been assessed in Volume 5, Report 6: Marine Conservation Zone Assessment. The potential for effects on European and Ramsar sites are assessed in Volume 5, Report 4: Report to Inform Appropriate Assessment (RIAA). |
| East Inshore Marine Plans | Policy SE-MPA-1: *Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of reference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate adverse impacts, with due regard given to statutory advice on an ecologically coherent network.* | Designated nature conservation sites within the VE study area have been described in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. Potential impacts to fish and shellfish features of designated sites have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. Impacts to marine conservation zones have been assessed in Volume 5, Report 6: Marine Conservation Zone Assessment. The potential for effects on European and Ramsar sites are assessed in Volume 5, Report 4: Report to Inform Appropriate Assessment (RIAA). No significant effects on the fish and shellfish features of designated sites |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | | have been identified. Therefore, no additional mitigation measures have been proposed, relative to features of designated marine protected areas. |
| | Policy SE-BIO-1: *Proposals that may have significant adverse impacts on the distribution of priority habitats and priority species must demonstrate that they will, in order of preference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate adverse impacts so they are no longer significant*<br>*d) compensate for significant adverse impacts that cannot be mitigated.* | Potential impacts on fish and shellfish priority species have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. No significant effects have been concluded for fish and shellfish priority species.<br>Potential impacts on priority habitats have been assessed in Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology. |
| | Policy SE-BIO-2: *Proposals that may cause significant adverse impacts on native species or habitat adaptation or connectivity, or native species migration, must demonstrate that they will, in order of preference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate adverse impacts so they are no longer significant* | Potential impacts on fish and shellfish receptors have been assessed in Sections 6.11, 6.12, 6.13 and 6.14 and mitigation detailed in Section 6.9 and 6.10. To summarise, prior to mitigation measures, significant effects from underwater noise and increased SSC and deposition on for spawning herring have been concluded and appropriate mitigation has been proposed in Table 6.12. Aside from this, no other significant effects have been concluded for fish and shellfish receptors, therefore no additional mitigation measures are proposed. |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
|---|---|---|
| | *d) compensate for significant adverse impacts that cannot be mitigated.* | |
| | Policy SE-INNS-1: *Proposals must put in place appropriate measures to avoid or minimise significant adverse impacts that would arise through the introduction and transport of invasive non-native species, particularly when:*<br>*1) moving equipment, boats or livestock (for example fish or shellfish) from one water body to another*<br>*2) introducing structures suitable for settlement of invasive non-native species, or the spread of invasive non-native species known to exist in the area.* | As detailed in Section 6.9, the implementation of a PEMP in accordance with Volume 9, Report 18, Outline PEMP, which will include a biosecurity plan, will ensure that the risk of potential introduction and spread of Invasive Non-Native Species (INNS) will be minimised. Potential impacts from the introduction and transport of invasive non-native species have also been assessed in Section 6.12 (Impact 12). |
| | Policy SE-DIST-1: *Proposals that may have significant adverse impacts on highly mobile species through disturbance or displacement must demonstrate that they will, in order of preference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate adverse impacts so they are no longer significant.* | Potential impacts from the disturbance or displacement of fish and shellfish receptors have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. To summarise, there have been significant effects concluded from increased SSC and deposition and underwater noise for spawning herring. Additional mitigation measures have therefore been proposed, these are summarised in Table 6.12. |
| | Policy SE-FISH-3: *Proposals that may have significant adverse impacts on essential fish habitat, including spawning, nursery and feeding grounds, and migratory* | Potential impacts on essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes have been assessed in Sections 6.11, 6.12, 6.13 |

| LEGISLATION/ POLICY | KEY PROVISIONS | SECTION WHERE COMMENT ADDRESSED |
| --- | --- | --- |
| | *routes, must demonstrate that they will, in order of preference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate - adverse impacts so they are no longer significant.* | and 6.14. To summarise, there have been significant effects concluded from increased SSC and deposition and underwater noise for spawning herring. Additional mitigation measures have therefore been proposed, these are summarised in Table 6.12. |
| | Policy SE-CE-1: *Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will, in order of preference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate adverse cumulative and/or in-combination effects so they are no longer significant.* | Cumulative effects are considered within Section 6.14. To summarise, there are no cumulative significant effects concluded on fish and shellfish receptors, therefore no additional mitigation measures are proposed. |
| | Policy SE-UWN-2: *Proposals that result in the generation of impulsive or non-impulsive noise must demonstrate that they will, in order of preference:*<br>*a) avoid*<br>*b) minimise*<br>*c) mitigate adverse impacts on highly mobile species so they are no longer significant.* | An assessment of potential impacts from underwater noise on fish and shellfish receptors has been undertaken in Sections 6.11 (Impact 1), 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). To summarise, significant effects were concluded from underwater noise on spawning herring. Additional mitigation measures have therefore been proposed, these are summarised in Table 6.12. |



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits

Marine Plan Areas:

- East inshore
- East offshore
- South East inshore

0 10 20 40
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

East Marine Plan Areas

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Issue | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.1

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|

FIVE ESTUARIES

## 6.3 CONSULTATION

6.3.1 As part of the Environmental Impact Assessment (EIA) for VE consultation has been undertaken with various statutory and non-statutory authorities, through the agreed Evidence Plan process (being used for the EIA process (inclusive of PEIR) as well as for the Habitats Regulation Assessment (HRA)). A formal Scoping Opinion was sought from the SoS following submission of the Scoping Report (VE OWF Ltd., 2021). The Scoping Opinion (PINS, 2021) was issued in November 2021 by Planning Inspectorate (PINS). The Section 42 (PEIR) consultation ran from 14th March 2023 to 12th May 2023. A comprehensive record of the key areas of consultation, the source of issues raised, and the specific measures taken to address each concern related to fish and shellfish ecology was documented during the Scoping Opinion process, Evidence Plan phases, Section 42 (PEIR) consultation and informal consultation, is summarised within Table 6.2 and presented in full within Volume 5, Report 1: Consultation Report.

**Table 6.2: Summary of consultation relating to Fish and Shellfish Ecology**

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| February 2020<br>Marine Ecology & Processes Expert Topic Group (ETG) | Eastern Inshore Fisheries and Conservation Authority (IFCA) highlighted that the MMO landing data has limitations in that smaller boat landings are not captured. Cefas also noted that shellfish species such as whelks and cockles would not be represented in the MMO landing data, and that beam trawl data would be insufficient, and requested a specific survey to be undertaken. Cefas also requested that the EIA include particle size analysis (PSA) for sandeel habitat suitability using the marine space methodology. | Data from Inshore Fisheries and Conservation Authority (IFCA) specific surveys have informed the information on whelk/cockle species (see Table 6.3). PSA data as collected within benthic characterisation surveys and BGS (2015) grab sample data have also been used to inform the fish and shellfish baseline, which is detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and summarised in Section 6.7. After an extensive review of existing survey data and literature, there is deemed to be sufficient baseline information available to characterise the fish and shellfish ecological assemblage. Therefore, conducting additional beam trawl surveys is considered counter-productive and potentially harmful to local fish communities. These existing survey data and literature are detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report; and are used to inform the assessments as undertaken in Sections 6.11, 6.12, 6.13 and 6.14. |
| February 2020<br>Marine Ecology & Processes Expert Topic Group (ETG) | It was agreed with Eastern IFCA, Cefas and Natural England that noise from UXO detonations should be scoped into the EIA and the potential for EMF impacts on fish and shellfish receptors should be included. | To inform the assessment of the potential impacts associated with underwater noise as a result of UXO clearance, a high-level consideration has been provided in Section 6.11 (Impact 1). It should be noted that UXO clearance will be consented under a |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | separate Marine Licence (post-consent) and will therefore not be consented under the DCO.<br>Potential impacts from EMF on fish and shellfish receptors have been assessed in Section 6.12 (Impact 13). |
| August 2021 MMO Response to the June 2021 Technical Note Fish and Shellfish Baseline Characterisation | MMO were content with the proposed approach of using data from existing sources, with data limitations acknowledged within the ES. The MMO confirmed they expect 10 years of IHLS survey data to be used and advised using Cefas data for Thames/ Blackwater herring. In the absence of a survey report focusing on whelks and cockles in the area, MMO recommended conducting a targeted survey or utilising the Thames Estuary Cockle Survey Report, 2018 (Dyer & Bailey, (2019) to inform of cockle presence in the area. The MMO recommended enquiring for additional data on cockles from the local IFCA. | Data limitations are described in Section 6.6. Data from the Cefas Blackwater herring surveys 1989-2009, the Kent and Essex Inshore Fisheries and Conservation Authority (KEIFCA) Thames Estuary Cockle Survey and the Thames Estuary cockle survey report 2018; Dyer & Bailey (2019) have been used to define the baseline characterisation as described in full in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and summarised in Section 6.7. Furthermore, 10 full years of IHLs data (2007-2022) have been used to define the baseline characterisation and inform the assessment of impacts on spawning herring as presented in Sections 6.11, 6.12, 6.13 and 6.14. |
| August 2021<br>Marine Ecology & Processes Expert Topic Group (ETG) | Cefas fisheries advisors were content that no additional fisheries surveys are required to inform the site characterisation for fisheries and fish ecology (with the exception of sediment grab samples to be collected as part of the benthic surveys, which will be used for PSA to inform seabed habitat suitability for spawning herring and sandeel). | This is noted, and no additional fisheries surveys have been undertaken. PSA data as collected within benthic characterisation surveys have been used to inform the fish and shellfish baseline which is summarised in Section 6.7, and to inform the assessments as undertaken in Sections 6.11, 6.12, 6.13 and 6.14. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| August 2021<br>Marine Ecology & Processes ETG | Cefas advised that direct impacts and damage on shellfish for sedentary species should be scoped into the EIA. | Potential impacts from direct damage on sedentary receptors have been assessed in Sections 6.11 (Impact 5), 6.12 (Impact 14) and 6.13 (Impact 21). |
| August 2021<br>Marine Ecology & Processes ETG | Essex County Council raised the local oyster farm industry and that it was a key consideration in the Bradwell B consideration. | Due consideration has been given to native oysters as a receptor throughout the assessments as undertaken in Sections 6.11, 6.12, 6.13 and 6.14. |
| November 2021<br>Natural England, Scoping Opinion | Natural England (NE) advises that spawning herring and sandeel are important prey components for many designated SAC and SPA species. Spawning grounds (for spawning herring, cod, lemon sole, sole, plaice, sandeel, whiting and cod) all overlap with the area where the Wind Turbine Generators (WTGs) are proposed to be built and would be exposed to greater impacts from noise due to the vicinity of the WTGs construction and operation to spawning areas. This should be made clearer in the text and include known temporal spawning information as well. | Reference to spawning grounds can be found in Section 6.7. Impacts from underwater noise are addressed in Sections 6.11, Impact 1, 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). |
| November 2021<br>Natural England, Scoping Opinion | The assessment should consider the potential for INNS spread via WTGs structures within the region. | INNS are addressed in Section 6.12 (Impact 12). |
| November 2021<br>Natural England, Scoping Opinion | The only migratory species sampled during the Galloper OWF surveys were twaite shad Alosa fallax, of which three were caught. Not capturing species during sampling could be due to the design and | Information on data sources can be found in Table 6.3. We have taken a precautionary approach and assumed presence of a species if found in any of the |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | timing of a survey. It does not indicate which species are not present, rather confirms which are. We therefore recommend that clarification is provided on whether the survey was carried out during a similar seasonal period as the proposed construction period for Five Estuaries, so its relevance can be determined. | data sources. Therefore, twaite shad have been included as a Valued Ecological Receptor (VER). |
| November 2021<br>Natural England, Scoping Opinion | Herring spawning grounds also overlap with the proposed array areas, on the far western side of the Study Area (Coull *et al*., 1998), and the far northern edge of the Study Area. Spawning herring and sandeel are important prey components for many designated SAC and SPA species. Spawning grounds (for spawning herring, cod, lemon sole, sole, plaice, sandeel, whiting and cod) all overlap with the area where the WTGs are proposed to be built and would be exposed to greater impacts from noise due to the vicinity of the WTGs construction and operation to spawning areas This should be made clearer in the text and include known temporal spawning information as well. | Reference to spawning grounds within the study area as well as overlapping with array areas have been addressed in Section 6.7. |
| November 2021<br>Natural England, Scoping Opinion | Sandeel are demersal spawners and are therefore considered sensitive to increased suspended sediment concentration (SSC) and subsequent sediment deposition. The area of study also includes | Impacts of SSC on sandeel spawning is addressed in Sections 6.11, (Impact 2) 6.12 (Impact 9), 6.13 (Impact 18) and 6.14 (Impact 25). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | large areas of sand which may be important for this species, which should be considered in the ES. | |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | The Scoping Report states that the affected species are likely to be mobile and can move away from disturbance and that the habitats likely to be disturbed represent a small area of the total distribution of that habitat type in the central southern North Sea.<br><br>The Inspectorate agrees that fish are generally a mobile receptor, however those species having a close affiliation with the seabed (for instance, sandeel and spawning herring) may be reliant on specific habitat for part of their life stages. In addition, sedentary shellfish species have limited ability to move in order to avoid danger. The Applicant's attention is drawn to the advice from the MMO on this point (see Appendix 2 of this report).<br><br>The Inspectorate considers therefore that direct damage and disturbance to mobile demersal and pelagic fish and shellfish species should be scoped into the assessment for all phases of the development. Accordingly, the ES should include an assessment of these matters or evidence demonstrating agreement with the relevant consultation bodies and the absence of an likely significant effect (LSE) on the environment. | Damage and disturbance to mobile demersal and pelagic fish and shellfish species has been scoped into this assessment and are addressed in Sections 6.11 (Impact 5), 6.12 (Impact 14), and 6.13 (Impact 21). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>PINS on behalf of SoS Scoping Opinion | Accidental pollution events resulting in potential effects on fish and shellfish receptors (for all phases of the development). The Scoping Report seeks to scope this matter out on the grounds that the risk of accidental pollution events will be mitigated through the implementation of an Environmental Monitoring Programme (EMP) and a Marine Pollution Contingency Plan (MPCP). However, the Scoping Report does not provide any detail on the content of these plans. In the absence of this information, the Inspectorate is not in a position to agree to scope this matter out of further assessment.<br>Accordingly, the ES should include an assessment of these matters or evidence demonstrating agreement with the relevant consultation bodies and the absence of an LSE on the environment. The Applicant's attention is drawn to the comments from the MMO on this point (see Appendix 2 of this report). | Impacts from potential accidental pollution events have been scoped into this assessment, through agreement under the Evidence Plan process and can be found in Section 6.11 (Impact 6), Section 6.12 (Impact 15) and Section 6.13 (Impact 22). |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | The Scoping Report seeks to scope this matter out from further assessment on the grounds that the assessment will consider the distribution of fish and shellfish species across the biogeographic region, irrespective of national jurisdictions. The Inspectorate agrees that the distribution of such species is independent of national geographical boundaries and agree that a specific assessment of transboundary | This is noted and Transboundary Effects on fish and shellfish receptors have not been assessed (Section 6.17). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | effects is unnecessary in relation to fish ecology. On this basis and given that transboundary impacts will be assessed in regard to commercial fisheries as part of the construction, operation and decommissioning phases of the Proposed Development, the Inspectorate is satisfied that this matter can be scoped out of the assessment. | |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | Sources of information from other OWF developments within the Outer Thames Strategic Area are proposed as sources of information for this aspect. Other developments in the area may provide further relevant data. Some of the identified data sources to be used are greater than 5 years old. The Applicant should ensure that the baseline data used in the ES assessments are sufficiently up to date to provide a robust baseline. The Applicant's attention is drawn to the advice from the MMO in Appendix 2 of this report on this point. | Noted, a broad combination of datasets has been used to provide a robust temporal analysis, these are summarised in Table 6.3 and detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | Baseline data: The Report states that should "sufficient information exist to enable a robust characterisation of the receiving environment, including identification of relevant valued fish and shellfish receptors, additional site-specific surveys are not proposed to be undertaken". If existing data is used, the ES should provide evidence to justify that it constitutes a robust characterisation of the receiving environment, with reference to the date, seasonal | Information on data sources, including temporal and spatial coverage are summarised in Table 6.3 and detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | period and geographic coverage of the data. Use of existing data should be done in agreement with consultees. | |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | The Scoping Report does not identify European seabass within the baseline environment for fish species. The wider Thames estuary supports bass populations as important Bass Nursery Areas (BNAs). The Inspectorate considers the assessment should consider potential impacts to seabass within the context of the proposed activities i.e., activities likely to disturb or potentially impact juvenile fish and nursery grounds. The Applicant's attention is drawn to the advice from the MMO in Appendix 2 of this report on this point. | European seabass nursery grounds have been included in Section 6.7 and assessed in Sections 6.11, 6.12, 6.13 and 6.14. |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | Direct removal of shellfish Table 10.3 does not include the impacts from the direct removal of shellfish. The ES should either include an assessment of this matter or provide a justification as to why such an assessment is not required, supported by evidence of agreement to this approach with relevant stakeholder. | Direct removal of shellfish has been addressed under the assessment of 'Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish' in Sections 6.11 (Impact 5), 6.12 (Impact 14) and 6.13 (Impact 21). Potential impacts to commercial fisheries are assessed in Volume 6, Part 2, Chapter 8: Commercial Fisheries. Impacts on shellfish as a result of disruption to fisheries are addressed under the assessment of 'Impacts on fishing pressure due to displacement' in Sections 6.11 (Impact 4) 6.12 (Impact 10) and 6.13 (Impact 20). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>PINS on behalf of SoS Scoping Opinion | The Eels Regulation 2009: The Inspectorate notes the potential for eels to be passing through the study area. No reference is made within the Scoping Report to the Eel Regulations 2009 nor Eel Recovery Plans. The ES should include reference to the Eel Regulations and any relevant requirements. The Applicant should agree the approach to meeting the requirements of the Eels Regulations with the EA and other relevant bodies, including any requirements for eel survey and the provision of eel and other fish pass facilities. | European eel have been recognised in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and have been considered and assessed under the relevant impacts in Sections 6.11, 6.12, 6.13 and 6.14 to meet the requirements of the Eels Regulations. No significant effects on European eel have been concluded. |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | Migratory species and designated sites: The Scoping Report states that river and sea lamprey and the allis and twaite shads are known to migrate through the study area. The Scoping Report lists two internationally designated sites of relevance to the Fish and Shellfish Ecology aspect. The ES should ensure that all sites designated for the migratory species that could interact with the Proposed Development are assessed, where significant effects are likely to occur. | Impacts to migratory species and designated sites have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. The conservation objectives for all designated sites for migratory species will be referred to within VE Report to Inform Appropriate Assessment (RIAA) and Volume 5, Report 6: Marine Conservation Zone Assessment. |
| November 2021<br>PINS on behalf of SoS Scoping Opinion | Impact on the spread of INNS The assessment should consider the potential for INNS spread via WTGs structures within the region. The ES should describe any necessary mitigation and / or biosecurity precautions required to prevent the spread of INNS. | The potential spread of INNS is assessed in Section 6.12 (Impact 12). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | Any measures relied upon in the ES should be discussed with relevant consultation bodies, including NE and the EA, in effort to agree the approach. Measures relied upon in the ES should be adequately secured. | |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | The Scoping Report proposes site-specific predictive noise modelling will be undertaken to assess the potential for mortality, permanent and temporary injury and behavioural disturbance of noise sensitive fish and shellfish receptors based on impact thresholds reported in Popper *et al.,* (2014). The Inspectorate notes the recommendations of the MMO on this matter (see Appendix 2 of this report) and therefore considers that fish should be treated as a stationary receptor in any modelling used to make predictions for noise propagation on fish spawning and nursery grounds. | Underwater noise modelling has been carried out on fish as both stationary and fleeing receptors to represent a range of potential impacts to underwater noise. See Sections 6.11 (Impact 1) 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | The outputs of modelling should be presented in map-form depicting the predicted noise impact range contours. The Inspectorate agrees with the MMO's recommendation that 10 years of IHLS data should be presented in the form of a 'heat map' which should be overlaid with the mapped noise contours. | IHLS data have been presented alongside the underwater noise impact range contours from Figure 6.12 to Figure 6.23. For the presentation of individual years of IHLS data see Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data). |
| November 2021 | The ES should make clear whether it is proposed to undertake simultaneous piling (i.e. the installation of | Simultaneous piling has been evaluated as part of the maximum design scenario (Table 6.10), which is |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| PINS on behalf of SoS Scoping Opinion | more than one pile at a time), in which case the underwater noise modelling for impacts to fish should be based on this scenario. | the basis for the assessment in Sections 6.11 (Impact 1) and 6.13 (Impact 17). |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | Mitigation measures<br><br>The Scoping Report does not state whether the Applicant intends to control the time of the proposed construction and / or operational activities to avoid key and sensitive periods to species, such as fish spawning seasons and fish migration periods. Mitigation measures to help reduce the impact of piling (i.e., soft start and ramp-up or twin walled piles) are not mentioned either. The ES should assess the duration of impacts in relation to the ecological cycles (e.g., life cycles, breeding and spawning seasons, etc.) of the receptors being assessed. | Mitigation relevant for the fish and shellfish ecology chapter is detailed in Table 6.11, which included the implementation of a piling MMMP (Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol – Piling, which details soft start and ramp up procedures.<br><br>The potential for impacts on fish and shellfish during key life events (such as spawning and migration, have been added in Sections 6.11, 6.12, 6.13 and 6.14. Where significant effects have been concluded, additional mitigation measures have been proposed, these are summarised in Table 6.12, and include a seasonal piling restriction and a sediment disposal restriction, implemented to mitigate against impacts to spawning herring. |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | Impacts from underwater noise and vibration during operation Impacts arising from underwater noise and vibration are scoped in for the construction and decommissioning phases (Table 10.3, impacts 10.1 and 10.9). Activities during maintenance work such as the use of jack-up barges and vessels will generate underwater noise and vibration. Accordingly, the ES should include an assessment of | The assessment of underwater noise from the operation and maintenance of VE can be found in Section 6.12 (Impact 8). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | these matters or evidence demonstrating agreement with the relevant consultation bodies that these activities are unlikely to give rise to LSE on the environment. | |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | Impacts from increases in SSC and sediment deposition during operation<br><br>Increases in suspended SSC and sediment deposition are scoped in for the construction phase (Table 10.3, impact 10.2). Activities such as the repair/replacement of inter-array and export cables and other windfarm infrastructures are likely to cause disturbance to seabed habitats, and temporarily increase SSC and sediment deposition.<br><br>Accordingly, the ES should include an assessment of these matters or evidence demonstrating agreement with the relevant consultation bodies and the absence of an LSE on the environment. The Applicant's attention is drawn to the comments from the MMO on this point (see Appendix 2 of this report). | References to sediment deposition are addressed for all project phases in Sections 6.11 (Impact 2), 6.12 (Impact 9), 6.13 (Impact 18) and 6.14 (Impact 25). Further details of the SSC modelling are available in Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. |
| November 2021<br><br>PINS on behalf of SoS Scoping Opinion | Temporary habitat loss/physical disturbance (all phases)<br><br>Temporary habitat loss/physical disturbance has not been included for further assessment. Construction activities such as sand wave clearance, ploughing | Temporary habitat loss is addressed in Sections 6.11 (Impact 7), 6.12 (Impact 16), 6.13 (Impact 23), and 6.14 (Impact 26). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | and jetting for seabed preparation and cable laying activities will cause temporary habitat loss and physical disturbance to benthic fish habitats. Similar effects are likely to occur as a result of maintenance work and decommissioning activities. Accordingly, the ES should include an assessment of these matters or evidence demonstrating agreement with the relevant consultation bodies and the absence of an LSE on the environment. The Applicant's attention is drawn to the comments from the MMO on this point (see Appendix 2 of this report). | |
| November 2021<br>Marine Management Organisation (MMO), Scoping Opinion | An additional data source for seahorses (benthic and inter-tidal ecology) is The Seahorse Trust (www.theseahorsetrust.org), which should be added. However, as this information is sensitive, we recommend that it is included as a separate confidential appendix to avoid release into the public domain. | Communication with the Seahorse Trust regarding this data source has been made, although unfortunately the information was not available to be publicly presented. A precautionary assessment of the potential impacts on seahorse from underwater noise has been undertaken in Sections 6.11 (Impact 1), 6.12 (Impact 8) and 6.13 (Impact 17) instead. |
| November 2021<br>MMO, Scoping Opinion | 2.3.7. MMO agree that the data sources and approach proposed by the Applicant to characterise fish and fisheries baselines and potential impacts are appropriate. However, to complement the baseline data, MMO recommend the following points to be taken into consideration for the PEIR and ES reports. | This is welcomed. |
| November 2021<br>MMO, Scoping Opinion | 2.3.8. Baseline Environment, the report provides a high-level fish ecology baseline and correctly | These species were recognised in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | identifies that the proposed windfarm array and offshore export cable corridor (ECC) are within or near to spawning and nursery grounds for several fish species (e.g., place, sole, cod, spawning herring and sandeel). MMO recognise that migratory fish species (e.g., Atlantic salmon, sea trout and European eel) and elasmobranchs (sharks, skates and rays), have also been discussed and will be further considered within the EIA which is appropriate. | Baseline Report and have been considered and assessed under the relevant impacts in Sections 6.11, 6.12, 6.13 and 6.14. |
| November 2021<br>MMO, Scoping Opinion | 2.3.9. MMO note that European seabass Dicentrarchus labrax have not been identified within the baseline environment for fish species. Please note that the wider Thames estuary supports bass populations as important BNAs. Seabass are a slow growing species that have suffered a long-term decline in population due to overfishing. As a result of declining stocks, seabass have been put under special protection measures since 2015 (MMO, 2017). MMO would expect the assessment to consider potential impacts to seabass within the context of the proposed activities i.e., activities likely to disturb or potentially impact juvenile fish and nursery grounds. The Applicant might wish to consider additional data sources to support the baseline description for this species (see comment 2.3.16). | European seabass nursery areas have been detailed in the baseline characterisation as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and summarised in Section 6.7, Potential impacts on seabass have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>MMO, Scoping Opinion | 2.3.13. Impacts arising from underwater noise and vibration have been scoped out for further assessment during the operational phase. MMO consider that at this early stage, the rationale provided for scoping out these impacts is ambiguous and does not clearly identify the magnitude of underwater noise generated during operation and maintenance activities. Activities during maintenance work such as the use of jack-up barges and vessels will generate underwater noise which must be considered in the assessment in the absence of such a rationale. | The assessment of underwater noise from the operation and maintenance of the VE OWF can be found in Section 6.12 (Impact 8). |
| November 2021<br>MMO, Scoping Opinion | 2.3.14. MMO recommend that increases in suspended sediment concentrations (SSC) and sediment deposition should also be scoped in during operation and maintenance phase. Activities such as the repair/replacement of inter- array and export cables and other windfarm infrastructures are likely to cause disturbance to seabed habitats, and temporarily increase SSC and sediment deposition. | Impacts from temporary increases in SSC and deposition during the operation and maintenance phase have been assessed in Section 6.12 (Impact 9). |
| November 2021<br>MMO, Scoping Opinion | 2.3.15. Direct damage and disturbance to mobile demersal and pelagic fish species has been scoped out of all phases of the development on the basis that affected species are likely to move away from disturbance. Figures 10.3, 10.4 and 10.5 of the scoping report show that the proposed works will | Direct damage and disturbance to mobile demersal and pelagic fish species in all phases of the development have been assessed in Sections 6.11, (Impact 5), 6.12 (Impact 14) and 6.13 (Impact 21). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | occur in spawning areas for mackerel, plaice, cod, spawning herring, lemon sole, sandeel and whiting. Whilst MMO agree that fish are generally a mobile receptor, those species with a close affiliation with the seabed (i.e., sandeel and spawning herring) or those that exhibit philopatric behaviour (i.e., returning to an area to spawn) may be reliant on a specific habitat for part or all of their life stages. MMO therefore recommend that direct damage and disturbance to mobile demersal and pelagic fish species is scoped into to all phases of the development. | |
| November 2021<br>MMO, Scoping Opinion | 2.3.16. MMO note that temporary habitat loss/physical disturbance has not been included for further assessment. Construction activities such as sandwave clearance, ploughing and jetting for seabed preparation and cable laying activities will cause temporary habitat loss and physical disturbance to benthic fish habitats. Similar effects are likely to occur as a result of maintenance work and Decommissioning activities, therefore MMO recommend that temporary habitat loss/physical disturbance is scoped in for assessment for all phases of the development. | Impacts from temporary habitat loss/disturbance in all phases of the development have been assessed in Sections 6.11 (Impact 7), 6.12 (Impact 16), 6.13 (Impact 23) and 6.14 (Impact 26). |
| November 2021<br>MMO, Scoping Opinion | 2.3.17. MMO recognise that potential impacts from accidental pollution have been scoped out for fish receptors. The Applicant has adequately justified that these potential effects can be scoped out based on | This is noted by the Applicant, however following consultation with PINS, this impact has been scoped into the assessment. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | the implementation of an PEMP and a Marine Pollution Contingency Plan (MPCP). | |
| November 2021<br>MMO, Scoping Opinion | 2.3.18. MMO note that the effects of EMF of fishes and elasmobranchs have been scoped into the EIA for the operational phase of the project only, which is appropriate. | Effects of EMF on fishes and elasmobranchs have been addressed in Section 6.12 (Impact 13). |
| November 2021<br>MMO, Scoping Opinion | 2.3.21. MMO is content that previous recommendations1 (e.g.,10 years of International Herring Larvae Survey (IHLS) survey data to be used to inform the assessment for Atlantic spawning herring) have been taken into account to inform the EIA. In MMO opinion, data sources outlined in section 10.3 (Table 10.1) of the scoping report and the proposed approach for data analysis are appropriate. | This is welcomed. 10 years of IHLS data have been used to inform the baseline characterisation as presented in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and to inform the assessment of potential impacts on spawning herring in Sections 6.11, 6.12, 6.13 and 6.14. Annual IHLS data are presented in Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data). |
| November 2021<br>MMO, Scoping Opinion | 2.3.22. Regarding seabass, the Applicant might wish to consider the Thames and Solent Bass Survey (Pickett *et al*., 2002; Walmsley 2005; 2006) and Young Fish Survey (Rogers *et al*., 1998) extracted from the Centre for Environment, Fisheries and Aquaculture (Cefas) Fishing Surveys System to support the identification of this species in the vicinity of VE. Additional data sources that could be used to inform the baseline for fish species can be found in Annex 1. | A full and robust characterisation is provided within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and is summarised in Section 6.7, using the most appropriate and contemporary data. A full and robust characterisation is provided within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and is summarised in Section 6.7, using the most appropriate and contemporary data. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>MMO, Scoping Opinion | 2.3.23. Furthermore, benthic sediment survey data will be collected across the VE array area. Sediment samples will be collected and analysed for Particle Size Analysis (PSA) and will be used to determine habitat suitability for spawning herring and sandeel. Data from benthic ecology surveys and PSA analysis for the North Falls OWF will also be reviewed, if available. MMO agree with this approach and using PSA data to support the characterisation of fish habitats. | Site-specific PSA data (Fugro, 2022a,b) has been used to inform the baseline and habitat suitability for spawning sandeel and spawning herring in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and is summarised in Section 6.7. PSA data has also been used to inform the assessments as presented in Sections 6.11, 6.12 and 6.13, in addition to PSA data from the North Falls OWF. This data has been utilised to visually represent the habitat suitability for herring and sand eel spawning in Figure 6.5 through Figure 6.9. |
| November 2021<br>MMO, Scoping Opinion) | 2.3.24. MMO support the use of the noise exposure thresholds identified in Popper *et al*., (2014) to underpin the EIA underwater noise assessment for fish. MMO recommend that fish are treated as a stationary receptor in any modelling used to make predictions for noise propagation on fish spawning and nursery grounds. MMO do not support the use of a fleeing animal model for fish the reasons outlined below:<br>MMO know that fish will respond to loud noise and vibration, through observed reactions including schooling more closely; moving to the bottom of the water column; swimming away, and; burying in substrate (Popper *et al*., 2014). However, this is not the same as fleeing, which would require a fish to flee | Underwater noise modelling has been carried out on fish as both stationary and fleeing receptors to present a range of responses. See Sections 6.11 (Impact 1), 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). Underwater noise modelling of stationary receptors to account for spawning activity for static demersal spawners such as herring, sandeel or eggs and larvae has been undertaken. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | directly away from the source over the distance shown in the modelling. MMO are not aware of scientific or empirical evidence to support the assumption that fish will flee in this manner.<br><br>The assumption that a fish will flee from the source of noise is overly simplistic as it overlooks factors such as fish size and mobility, biological drivers, and philopatric behaviour which may cause an animal to remain/return to the area of impact. This is of particular relevance to spawning herring, as they are benthic spawners which spawn in a specific location due to its substrate composition.<br><br>Eggs and larvae have little to no mobility, which makes them vulnerable to barotrauma and developmental effects. Accordingly, they should also be assessed and modelled as a stationary receptor, as per the Popper *et al*., (2014) guidelines. | |
| November 2021<br><br>MMO, Scoping Opinion | 2.3.25. The outputs of modelling should be presented in map-form depicting the predicted noise impact range contours. 10 years of IHLS data should be presented in the form of a ‘heat map’ which should be overlaid with the mapped noise contours. This will provide a better understanding of the likely extent of noise propagation into herring spawning grounds and allow for a more robust assessment of impacts to be made. | IHLS data have been presented alongside the underwater noise impact range contours from Figure 6.12 to Figure 6.23. For the presentation of individual years of IHLS data see Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>MMO, Scoping Opinion | 2.3.26. The Applicant should clearly state in their ES (and PEIR if applicable) whether they propose to undertake simultaneous piling, i.e., the installation of more than one pile at a time, for the installation of WTGs or other offshore platform structures. If simultaneous piling is proposed, then underwater noise modelling for impacts to fish should be based on this scenario. | Simultaneous piling has been assessed as part of the maximum design scenario assessed, which details piling installation (Table 6.10) and informs the assessments in Sections 6.11 (Impact 1), 6.12 (Impact 8), 6.13 (Impact 17) and 6.14 (Impact 24). |
| November 2021<br>MMO, Scoping Opinion | 2.3.27. As previously suggested, data limitations should be acknowledged within the ES e.g., the age of the data, fishing gear selectivity, and timing of surveys in relation to seasonal presence/absence/abundance of species. | Data limitations are addressed in Section 6.6. |
| November 2021<br>MMO, Scoping Opinion | 2.3.28. MMO agree with the Applicant that given the amount of existing data available and the usefulness of sporadic fish surveys undertaken in the area, no site- specific fisheries surveys will be undertaken for VE. | This is noted, a summary of the data utilised to inform the baseline characterisation and assessment is provided in Table 6.9. |
| November 2021<br>MMO, Scoping Opinion | 2.3.29. MMO note that a number of mitigation measures such as following industry best practice to cover accidental spills and contaminant release are proposed to reduce the potential impacts on fish receptors. MMO agree these are appropriate at this early stage. | Noted. Mitigation can be found in Section 6.9 and best practices have been applied. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>MMO, Scoping Opinion | 2.3.30. The Applicant proposes the use of soft start procedures on commencement of piling which MMO support. It is recommended that a 20-minute soft-start in accordance with Joint Nature Conservation Committee (JNCC) protocol for minimising the risk of injury to marine mammals and other fauna from piling noise (JNCC 2010). Should piling cease for a period greater than 10 minutes, then the soft-start procedure must be repeated. | Noted. Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol (MMMP) – Piling, will include soft start procedures as discussed in Table 6.11. |
| November 2021<br>MMO, Scoping Opinion | 2.3.32. Species-specific mitigation has not been proposed at this stage for fish receptors, which is to be expected as these can only be identified, as necessary, once the EIA has been completed. | This is noted, mitigation has however been detailed in Section 6.9. |
| November 2021<br>MMO, Scoping Opinion | 2.3.33. Cumulative, inter-related and transboundary impacts have been properly identified in Chapters 4.6-4.8 and 10.5 (for fish) and these will be considered for further assessment within the scoping report. Although no specific projects have been included at this stage, MMO agree the methodology to be used is appropriate and fit for purpose. | Noted. Cumulative impacts are addressed in Section 6.14, inter-relationships are addressed in Section 6.15 and transboundary effects are addressed in Section 6.17. |
| November 2021<br>MMO, Scoping Opinion | 2.3.34. Monitoring measures have not been discussed in the context of fish receptors at this early stage of the planning process. The need for any additional monitoring should be determined upon the outcomes of the EIA. | Noted. No monitoring requirements have been identified based on the findings of the assessment. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br><br>MMO, Scoping Opinion | 2.3.35. There are some minor and typographic errors within the scoping report which have been detailed below;<br><br>The correct reference for the Spawning and nursery grounds of selected fish species in UK waters is "Ellis *et al*., 2012" and not "Ellis *et al*., 2010" as referred to throughout Section 10 (Fish and Shellfish resource).<br><br>Coull *et al*., 1998 is not referenced within Table 10.1 (section 10) though is properly cited throughout the document and reference list.<br><br>Section 10.4.13 – Atherina presbyter should be referenced as sand smelt, rather than smelt, as this could be confused with the European smelt Osmerus eperlanus, unless the latter is the intended species referred to in the scoping report. Especially as O. eperlanus has several conservation designations including being listed as species of principal importance under section 41 (England) of the NERC Act (2006).<br><br>European seabass Dicentrarchus labrax, although mentioned as a commercial species within Section 13, has not been further described in the fish baseline section. | All instances of Ellis *et al.,* 2010 have been corrected to 2012.<br><br>Noted, reference to Coull *et al*., 1998 has been added to Table 6.3.<br><br>The intended species of reference is the European smelt (*O. eperlanus*), due to its conservation status.<br><br>European seabass nursery areas have been included in the baseline characterisation, as detailed in full in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and summarised in Section 6.7. European seabass nursery areas have been included in the baseline characterisation, as detailed in full in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and summarised in Section 6.7. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br><br>MMO, Scoping Opinion | 2.3.36. Overall, appropriate fish receptors, potential impacts on fish receptors and commercial fisheries have been identified within the scoping report. Nonetheless, MMO recommend that direct damage and disturbance to mobile demersal and pelagic fish species and UWN and vibration during the operational phase are considered further or that evidentiary support is provided to justify scoping these impacts out of the assessment. Additionally, MMO recommend that temporary habitat loss/physical disturbance during construction, operation and decommissioning is included for further assessment in the PEIR and ES. | Direct damage and disturbance to mobile demersal and pelagic fish species during the operational phase is addressed in Section 6.12 (Impact 14).<br><br>Temporary habitat loss/physical disturbance is addressed in Sections 6.11 (Impact 7), 6.12 (Impact 16), 6.13 (Impact 23) and 6.14 (Impact 26). |
| November 2021<br><br>MMO, Scoping Opinion | 2.3.37. We advise that seabass is given detailed consideration in the context of the current special protection measures for seabass stocks, in relation to potential impacts on juvenile fish. | European seabass and their nursery grounds across the region have been given due consideration in in Volume 6, Part 5 Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and Section 6.7, and potential impacts on European seabass have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. European seabass and their nursery grounds across the region have been given due consideration in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and Section 6.7, and potential impacts on European seabass have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>MMO, Scoping Opinion | 2.3.38. Additional evidence sources have been recommended which may provide additional local and regional data on fish and elasmobranch populations. | Noted. Data sources are listed in Section 6.4. |
| November 2021<br>MMO, Scoping Opinion | 2.4.1. The approach provided by the applicant is in line with what would be expected for this type of development and therefore is expected to be sufficient to fully identify and assess potential impacts. | This is welcomed. The impacts identified are listed in Section 6.4, and the assessment of potential impacts is provided in Sections 6.11, 6.12, 6.13 and 6.14. |
| November 2021<br>MMO, Scoping Opinion | 2.4.2. Direct removal from the fishery should be scoped into the impact assessment; this will apply to any phase of development that may potentially crush shellfish. This is particularly important in sedentary shellfish species which have limited capabilities to move in order to avoid danger. All other potential impacts have been identified. | The sensitivity of shellfish to damage through crushing is addressed in Section 6.11 (Impact 5), Section 6.12 (Impact 14) Section 6.13 (Impact 21). |
| November 2021<br>MMO, Scoping Opinion | 2.4.3. There are no identified data gaps that need highlighting, the applicant has appropriately used a combination of desk-based sources, previous site-specific surveys and landing statistics for identifying the baseline characteristics of the proposed site. The information sources identified are expected to provide sufficient baseline information, though please refer to "Additional comments" (point 2.4.6) concerning data timeliness. | This is noted, a summary of the data utilised to inform the baseline characterisation and assessment is provided in Table 6.9. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| November 2021<br>MMO, Scoping Opinion | 2.4.4. The applicant has provided information of project level mitigations. Shellfish specific mitigations are not expected at this stage of the application. Mitigations are only required if a species of shellfish is found to be significantly impacted when assessed against the potential impacts, which cannot be determined at the scoping stage. | This is noted, mitigation has however been detailed in Section 6.9. |
| November 2021<br>MMO, Scoping Opinion | 2.4.5. The potential for cumulative and inter-related impacts and effects is not expected to be fully considered at this stage as shellfish have not been assessed against the potential impacts which identifies individual impact. The applicant has outlined likely potential cumulative impacts if species are identified as being susceptible, which is appropriate. | Cumulative effects are addressed in Section 6.14 and inter-relationships are addressed in Section 6.16. |
| November 2021<br>MMO, Scoping Opinion | 2.4.6. The applicant has identified data sources to be used and is heavily reliant on data which are greater than 5 years old. MMO would only consider data collected within the last 5 years to be representative of the species composition at the proposed site. When reviewing the impact of the proposed development on shellfish, emphasis should be put on the survey data collected in the last 5 years. MMO would also note that when using data collected using gear not designed to capture shellfish (e.g., beam trawl), any conclusions made about shellfish should | Full details on the data sources and the utilisation of each data source is provided in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. Data collected within the last 5 years have been used to inform the fish and shellfish baseline characterisation. Furthermore, caveats about the fishing gear used to capture shellfish have been addressed in Section 6.6, and in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | be caveated with this information and data from these surveys should only be used for presence/absence and not abundance estimates. | |
| November 2021<br><br>MMO, Scoping Opinion | 2.4.7. The applicant has provided a well outlined approach that is expected to be sufficient to identify and assess impacts. Direct removals from the fishery should be scoped into the impact assessment for shellfish. | Direct removal of shellfish has been addressed under the assessment of 'Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish' in Sections 6.11, 6.12 and 6.13. Potential impacts to commercial fisheries are assessed in Volume 6, Part 2, Chapter 8: Commercial Fisheries. Impacts on shellfish as a result of disruption to fisheries are addressed under the assessment of 'Impacts on fishing pressure due to displacement' in Sections 6.11, 6.12 and 6.13. |
| November 2021<br><br>MMO, Scoping Opinion | 2.5.2. For fish and shellfish receptors (Section 10.2.1 and Table 10.3) it is proposed that site-specific predictive noise modelling will be undertaken to assess the potential for mortality, recoverable injury and behavioural disturbance of noise on sensitive fish and shellfish receptors based on impact thresholds reported in Popper *et al*., 2014). Impacts scoped into the assessment for fish and shellfish receptors are construction activities (pile driving and unexploded ordnance (UXO) clearance) and decommissioning activities (increased vessel movements and removal of the WTGs foundations) (Table 10.3). The worst-case scenario will be based on WTG foundation type and size, and water depths in which they will be | Underwater noise modelling undertaken is detailed in full in Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report. The modelling has been used to inform the assessment of potential impacts from underwater noise on fish and shellfish receptors in Sections 6.11 (Impact 1), 6.12 (Impact 8) 6.13 (Impact 17) and 6.14 (Impact 24).<br><br>To inform the assessment of the potential impacts associated with underwater noise as a result of UXO clearance, a high-level consideration has been provided in Section 6.11. It should be noted that UXO clearance will be consented under a separate Marine |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | deployed (Section 10.6). This approach is appropriate to identify and assess the potential underwater noise impacts on fish and shellfish receptors, however, please see points 2.5.7 and 2.5.8 below regarding additional potential impacts to be scoped into the assessment. | Licence (post-consent) and will therefore not be consented under the DCO. |
| November 2021<br>MMO, Scoping Opinion | 2.5.12. The potential spatial and temporal cumulative effects on fish and finfish receptors have been adequately described in Section 10.5.10. | This is welcomed. The assessment of cumulative effects on fish and shellfish receptors has been undertaken in Section 6.14. |
| December 2021<br>Marine Ecology & Processes ETG | It was agreed with Natural England, the MMO and Cefas that impacts from increased SSC and deposition during the O&M phase of the development will be scoped in. | Impacts from increased SSC and deposition during the operation and maintenance phase on fish and shellfish receptors have been assessed in Section 6.12 (Impact 9). |
| December 2021<br>Marine Ecology & Processes ETG | It was agreed the potential for INNS to colonise installed infrastructure should be considered under the impact 'increased hard substrate and structural complexity as a result of the instruction of WTGs foundations, scour protection and cable protection. | As agreed, impacts from INNS are addressed in Section 6.12 (Impact 12). |
| December 2021<br>Marine Ecology & Processes ETG | Seabass were identified as a key species in the Scoping Opinion. VE will undertake a review to understand the distribution and seasonality of seabass. | European seabass and their nursery grounds across the region have been given due consideration in Section 6.7 (Figure 6.10) and have been assessed in Sections 6.11, 6.12, 6.13 and 6.14. |
| December 2021<br>Marine Ecology & Processes ETG | It was agreed that fish will be modelled as both stationary and fleeing receptors, and the ecologically appropriate threshold assessed. | Underwater noise modelling has been carried out on fish as both stationary and fleeing receptors, and has been used to inform the assessment of potential |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | impacts on fish and shellfish receptors in Sections 6.11, 6.12, 6.13 and 6.14. |
| November 2022<br>Underwater Noise, Fish and Shellfish Ecology and Marine Mammals ETG | Essex County Council highlighted that UXO may be present based on unpublished information. Essex County Council stated that in-combination effects of noise will occur with VE construction and other windfarms being constructed at the same time. It was agreed to investigate the likelihood of cumulative impact of North Falls and VE constructing simultaneously. | To inform the assessment of the potential impacts associated with underwater noise as a result of UXO clearance, a high-level consideration has been provided in Section 6.11. It should be noted that UXO clearance will be consented under a separate Marine Licence (post-consent) and will therefore not be consented under the DCO. The likelihood of cumulative impact of VE and other projects including North Falls OWF constructing simultaneously, and the effects of noise have been assessed in Section 6.14. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5 Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | The MMO raised the concern that it is unclear which other parameters have been used in the underwater noise modelling to determine the impact range of 39 km. | The impact range of 39 km has been defined by the parameters used to inform the noise modelling as set out in Table 6.14. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of | The MMO do not support the use of a fleeing fish receptor in underwater noise modelling. | Underwater noise modelling has been carried out on fish as both stationary and fleeing receptors to ensure a range of responses are modelled. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | | |
| November 2022<br><br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | The thresholds and parameters used in the modelling for existing OWF projects is not stated within Table 2.1 and the predicted impact ranges are likely to differ to those for the VE project. | The thresholds and parameters used to determine the predicted impact ranges can be found in Table 6.14 and Table 6.16. |
| November 2022<br><br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | If simultaneous piling is proposed during construction at VE, this scenario should be modelled in the Maximum Design Scenario (MDS). | Simultaneous piling has been assessed as part of the maximum design scenario assessed, which details piling installation (Table 1.10) and informs the assessments in Sections 6.11 to 6.14, Impacts 1, 8, 7 and 24. |
| November 2022<br><br>Pre PEIR-Submission. MMO comments following submission of Volume 6, Part 5, Annex | The MMO recommend that modelling for the received levels of single strike sound exposure levels ($SEL_{ss}$) at the herring spawning grounds are presented based on 135 dB threshold. | Whilst Hawkins *et al*., (2014a) present a possible threshold for behavioural impacts on fish, the use of this threshold for noise impact assessments is expressly advised against by the authors of the paper. Specifically, this threshold is based on a study |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| 6.1: Fish and Shellfish Ecology Technical Baseline Report | | undertaken within a quiet loch on fish not involved in any particular activity (i.e. not spawning), and it is therefore not considered appropriate to use this threshold within a much noisier area such as the southern North Sea (which is subject to high levels of anthropogenic activity and consequently noise) as the fish within this area will be acclimated to the noise and would be expected to have a correspondingly lower sensitivity to noise levels. Also, as demonstrated by Skaret *et al*., (2005), herring are much less likely to respond to sound when engaged in life-history critical activities (e.g., feeding, spawning). The use of the 135 dB threshold is not considered meaningful when attempting to describe the potential disturbance effects on spawning herring arising from piling activity. However notwithstanding this, VE has presented potential behavioural impact ranges as 5dB increments from the piling source (Figure 6.22 and Figure 6.23) and undertaken a literature review to inform the potential range and magnitude of effects on sensitive receptors. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish | The maps for herring and sandeel spawning and nursery grounds in the VE region are at a rather small scale and the map keys are difficult to read which makes interpretation of the maps difficult, especially the PSA data coverage. The MMO recommend that larger scale maps detailing seabed sediments, | This is noted, and larger scale maps have been presented. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| Ecology Technical Baseline Report | broadscale BGS data and historic spawning grounds are presented in the PEIR and ES. | |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | Care should be taken when interpreting the findings go the Brown and May Ltd (2009) Thames herring spawning survey undertaken for Gunfleet Sands OWF, as discussed in Section 3.1.29. The surveys did not include any further investigation into physiological damage to herring or their eggs and larvae that may have resulted from piling. Furthermore, the survey was taken for one year's spawning season only, so there are insufficient data to infer the duration of the spawning period. | This has been noted and acknowledged within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | Until recently the Southern North Sea and eastern English Channel IHLS surveys from the Downs herring population were conducted as three separate sampling event surveys. However, one survey was discontinued in 2017 (ICES 2021) so this should be bourne in mind when downloading and interpreting the IHLS data. | This has been noted and acknowledged within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex | There is a typo in Section 3.1.41 and Tables 3.2 and 3.4 which refers to albacore tuna and 'Bluefin tuna'. | All instances of 'bluefin tuna' have been corrected to 'albacore'. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| 6.1: Fish and Shellfish Ecology Technical Baseline Report | | |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | There is a typo in Sections 3.1.63-65 which refers to twaite shad as 'thwaite' shad.<br><br>Also, in reference to allis shad in Section 3.1.64 'there are now no known spawning sites for this species in Britain', allis shad are understood to spawn at one location in the UK in the river Tamar (see Hillman, 2020). | The typo has been corrected.<br><br>This sentence has been removed and Hillman (2020) has been referred to within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | The MMO with the advice of Cefas support the approach in Table 3.4 of classifying VERs that may be sensitive to the potential impacts which may arise during the construction, O&M, and decommissioning of the array. However, it is recommended that VERs for the ECC are also included. | This has been corrected within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. The VERs identified are applicable to the ECC as well as the array areas. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex | The MMO agreed that the relevant and appropriate data sources were identified to describe the baseline. Although suggested making use of the crab and lobster stock assessments to inform the baseline environment (Cefas (2020). Edible crab (*Cancer pagurus*). Cefas Stock Status Report 2019 18 pp. | This is noted and the baseline characterisation within Volume 6, part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report has been updated to include reference to the crab and lobster stock assessments. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| 6.1: Fish and Shellfish Ecology Technical Baseline Report | and Cefas (2020). Lobster (*Homarus gammarus*). Cefas Stock Status Report 2019 18 pp.) | |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | The MMO noted that the MMO UK Sea Fisheries Monthly Reports and Annual Statistics Reports, had been used to inform the baseline characterisation. The MMO agreed with this approach. The MMO however, recommended using a time series of at least 5 years to characterise the shellfisheries. | This is noted and the baseline characterisation within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report has been updated to include the last five years of available data from the MMO UK Sea Fisheries Monthly Reports and Annual Statistics Reports to characterise the shellfisheries. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | The MMO noted that within the data limitations section, it was acknowledged that methods of surveying fish and shellfish vary in their efficiency at capturing different species, and that otter and beam trawl surveys are ineffective at capturing information on pelagic fish species (such as herring (*Clupea harengus*) and sprat (*Sprattus sprattus*)). The MMO added that these methods are also not effective at capturing shellfish species such as edible crab, common lobster and whelks. | This has been acknowledged in the Data Limitations Section of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of | The PEIR states “sensitive receptors have been chosen based on their presence or absence in surveys, rather than whether that species contributes more significantly to the fish assemblage in the survey data.” Could you provide a list of species | This is noted, and Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report has been updated to make reference to any sensitive species to VE where recorded as present in surveys. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | present in the NSIBTS survey and confirm whether all species present in the survey will be included. If not all species are included, could you provide a list of which species it intends to include as sensitive receptors. | |
| November 2022<br>Pre PEIR Submission. MMO comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | Natural England (and Cefas) recommend that a stationary receptor is used when assessing impacts from piling noise on fish. Whilst VE has included this, it is not clear from the modelling if the ZoI calculations included impacts to only adult fish or includes juveniles and eggs as well. Impacts on the species should encompass both. | The potential for impacts from piling noise on eggs and larvae is assessed in Sections 6.11 (Impact 1), 6.12 (Impact 8) and Section 6.13 (Impact 17). |
| November 2022<br>Pre PEIR Submission. Natural England comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | Whilst unsuitable spawning grounds have been identified, this detracts from the fact that there are still large areas across the ZoI (and close to the array) that are prime/preferred or suitable/marginal for both herring and sandeel. Figure 3.7 shows large areas with preferred/favourable grounds for sandeel, similarly there is a large gap to the north of the site without PSA data, yet the seabed substrate is the same as, or similar to the areas with favourable sandeel habitat. Therefore, can it be clarified whether seabed substrate and nearby PSA results will be used instead to infer whether this whole area is also suitable for sandeel spawning? The location and | Detailed description of spawning ground habitats across the study area and wider region have been provided in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, with a summary provided in Section 6.7. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | extent of all suitable habitat within the ZoI should be clearly presented. | |
| November 2022<br>Pre PEIR Submission. Natural England comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | In Figure 3.1, why are ICES rectangles to the south not included (31F1 and 31F2) as they fall within the ZoI? | This is noted, and the figure has been amended to show ICES rectangles 31F1 and 31F2 within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| November 2022<br>Pre PEIR Submission. Natural England comments following submission of Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report | Thames Blackwater herring are recognised as separate stock, so impacts on their spawning/nursery grounds could have a detrimental impact to that discreet stock, regardless of whether their specific spawning ground is considered a key importance to the wider herring stocks. This should be assessed and addressed within the wider EIA.<br>Can it be inferred that the shorter than anticipated spawning period for the herring stock and the more inshore location utilised by the fish was not influenced by the piling noise created by the windfarm in construction? | The Thames Blackwater herring stocks and Downs herring stocks have been assessed as separate stocks throughout the assessments in Sections 6.11 to 6.14.<br>The survey commissioned by Gunfleet Sands Limited (Brown and May Ltd., 2009) was carried out for one spawning season of the Thames Blackwater herring stock, so there are insufficient data to infer the duration of the spawning period. As a precautionary approach, the spawning period as defined by Coull *et al.*, (1998) has been used to inform this assessment. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| Natural England January 2024<br><br>S42 Consultation | The use of a fleeing receptor continues to be used in modelling of underwater noise impacts on fish. Natural England do not agree with the use of this, as there is insufficient evidence in the literature presented to back this up in a real-world scenario.<br><br>Natural England advise that fish are treated as a stationary rather than fleeing receptor throughout the submitted ES. | Underwater noise modelling has been carried out on fish as both stationary and fleeing receptors to ensure a range of responses are modelled. The outputs of the modelling are detailed in Section 6.11 Impact 1, 6.12 Impact 8, and 6.13 Impact 17. |
| Natural England (2024) S42 Consultation | Impacts to the Downs herring stock due to construction related activities due to the Project alone and in combination with other developments.<br><br>As well as being a receptor in their own right, herring are important prey components for many designated SAC and SPA species and the potential for impacts to them due to the VE project alone and in-combination need to be fully considered and assessed further. | The Applicant acknowledges the importance of herring as a key prey species of many SPA and SAC features. A comprehensive assessment of the potential impacts from the development on spawning herring from both the Downs and the Blackwater stocks has been undertaken and its detailed in Sections 6.11, 6.12 and 6.13 of this chapter. The conclusions of the assessments are summarised in Table 6.44, and any additional mitigations proposed are detailed in Section 6.10. |
| Natural England (2024) S42 Consultation | Please note that for advice on underwater noise impacts to fish, Natural England defer to Cefas. To note. | This is noted by the Applicant. |
| Natural England (2024)<br><br>S42 Consultation | The relevant fish receptors have been identified for the study area (however, we note albacore tuna has been included but not bluefin tuna which is more | This is noted by the Applicant. Bluefin tuna have been incorporated as a VER into Volume 6, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and the assessment as a VER (Table 6.9), |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | likely to be present). No further recommendations (with the exception of bluefin tuna). | |
| Natural England (2024)<br>S42 Consultation | The worst-case scenario is largely suitable, with the exception of impacts to the Downs herring stock. Please see our comments below on the relative importance of the Downs herring stock and potential impacts of overlap with VE study area. | The Applicant welcomes Natural England's agreement of the suitability of the worst case scenario presented. The Applicant confirms that a comprehensive assessment of the potential impacts from the development on spawning herring has been undertaken, and is detailed in Sections 6.11, 6.12 and 6.13. The conclusions of the assessments are summarised in Table 6.44, and any additional mitigation proposed are detailed in Section 6.10. |
| Natural England (2024)<br>S42 Consultation | We understand that project-specific benthic ecology surveys (including Particle Size Analysis) will be undertaken across the arrays and within the offshore export cable corridor (ECC). It is intended that these will be used to inform on spawning habitat suitability for demersal spawning fish (e.g. spawning herring and sandeel). We advise that this assessment should be updated when the information is available. We may have further comments following review of this information. | The Applicant confirms that site specific benthic and geophysical survey data from across the array areas and offshore ECC have been used to inform spawning habitat suitability assessment for spawning herring and sandeel. These data have been incorporated into a heatmapping exercise, undertaken in accordance with the MarineSpace (2013a and 2013b) methodologies (as advised by the MMO) (see Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report for the updated fish and shellfish baseline, and Section 6.7 for a summary of the existing environment). |
| Natural England (2024)<br>S42 Consultation | We note that the Applicant has suggested existing literature/survey data is sufficient to provide a baseline for EIA, and that additional site specific | This is noted by the Applicant. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | surveys are not proposed. Natural England defer to Cefas on this matter. | |
| Natural England (2024) S42 Consultation | We note that data sources used to inform the fish baseline characterisation and assessment include those from existing OWFs such as Gunfleet Sands, Galloper, Greater Gabbard and London Array.<br>In line with our earlier Scoping Response (02 November 2021), we advise that supporting information relating to the suitability of survey data from relevant existing OWFs should be provided in the ES. For example, the suitability and similarity of timing of survey data from the existing OWFs compared to the proposed Five Estuaries OWF construction period, so that the applicability and relevance of their data can be determined. | The Applicant confirms that limitations relating to the use of survey data from relevant existing OWFs to inform the baseline characterisation and assessment are detailed in Section 6.6. The Applicant confirms that these data sources represent snapshots of the fish and shellfish assemblage within the study area at the time of sampling, and the fish and shellfish assemblages may vary considerably both seasonally and annually. However, should species be absent from the OWF surveys, the outcome is not to exclude consideration of these species from the baseline characterisation. Rather, the baseline description draws upon (or defaults to) wider scientific literature, as this provides a more thorough, robust, and longer time series evidence base. |
| Natural England (2024) S42 Consultation | The data sources used by the Project are generally appropriate. However, we defer to Cefas for recommendations of further data sources to complement these data and any potential requirement for additional data. | This is noted by the applicant. |
| Natural England (2024) S42 Consultation | Currently, there is contradictory evidence regarding the potential importance of the VE study area to the Downs herring stock. Please provide clarity and further supporting information. | The Applicant has undertaken a spawning habitat suitability assessment for spawning herring to identify areas of importance to the Downs herring spawning stock within the study area. This assessment has |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | consisted of a heatmapping exercise, undertaken in accordance with the MarineSpace (2013a and 2013b) methodologies (as advised by the MMO) (see Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report for the updated fish and shellfish baseline, and Section 6.7 for a summary of the existing environment). |
| Natural England (2024) S42 Consultation | Please see our comment above. We advise consideration of the aforementioned data gap and consider need for further data analysis/modelling. | Noted by the applicant, please see the Applicant's response to the above comment. |
| Natural England (2024) S42 Consultation | Spawning Herring. We do not agree that the sensitivity of spawning herring to noise impacts would be medium during the construction phase of the Project.<br><br>We would advise that the sensitivity of spawning herring to underwater noise impacts should be assessed as greater than medium. | The Applicant concludes medium sensitivity for spawning herring due their regional importance, and their possession of a swim bladder that is involved in hearing. This is in accordance with the sensitivity criteria outlined in Table 6.5. |
| Natural England (2024) S42 Consultation | With piling predicted to last for a period of 12 months, this means that potentially 100% of the spawning period for all species within the impact zone will be impacted by noise.<br><br>The submitted ES should clarify whether this is indeed the WCS. | To ensure a precautionary temporal assessment, the Applicant has assumed that all piling will occur within the entirety of the spawning periods for all receptors. However, piling activities are considered temporary and intermittent, therefore, the actual temporal impact on the receptors will be significantly less than 12 months. See Volume 6, Part 5, Annex 6.2: Underwater Noise Report, which describes the length |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | of time taken for the MDS for monopiling and pin piling. |
| Natural England (2024) S42 Consultation | The potential for mortality does not equate to a low magnitude of impact, especially with regard to the current condition of the fishery – see Section 6.7.25.<br><br>We do not agree with this rationale and recommend this assessment is revised. | The Applicant has presented the impact range underwater noise contours for mortality and potential mortal injury for the worst-case piling scenarios in relation the Downs herring stock spawning ground, and larval densities as recorded in annual IHLS. Due to the localised nature of the impact ranges, and the low densities of herring larvae located within the impact contours (high intensity spawning activity for the Downs herring stock occurs consistently in the English Channel as indicated by high densities of herring larvae recorded in annual IHLSs) the Applicant is confident that the assessment of low magnitude impacts for the potential for mortality and potential mortal injury is appropriate. |
| Natural England (2024) S42 Consultation | The impact of mortality and potential mortal injury on the Downs herring stock is considered to be of low magnitude. However, we advise that considering the Downs Herring is a separate stock, the assessment should take that into account. If there is potential for mortality and permanent threshold shifts, then we advise that this would not be of low magnitude.<br><br>We advise that the submitted assessment should be updated to reflect the impacts of potential mortality and threshold shifts on a distinct stock. | A comprehensive assessment from the impacts of underwater noise on both Downs and Blackwater herring as discrete stocks has been undertaken. This is detailed in Section 6.11 Impact 1, 6.12 Impact 8, and 6.13 Impact 17.<br><br>The Applicant is confident that due to the localised nature of the mortality and potential mortal injury impact ranges, and the low densities of herring larvae located within the impact contours (high intensity spawning activity for the Downs herring stock occurs |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | consistently in the English Channel as indicated by high densities of herring larvae recorded in annual IHLSs), there will be no population level effects on the Downs or the Blackwater herring spawning stocks. Therefore, a conclusion of a low magnitude of impact is considered appropriate. |
| Natural England (2024) S42 Consultation | A maximum area for in combination effects of 5300 $km^2$ and 4800 $km^2$ are large areas. Even though the distribution of receptors is fairly broadscale this still equates to a large area that will be impacted. Therefore, we would not conclude that this is negligible. We would advise that this is not negligible and consider the conclusions of the submitted ES should reflect the size of the impacted areas. | The Applicant has presented the impact range underwater noise contours for the worst case piling scenarios from concurrent piling in relation key fish and shellfish receptors in Figure 6.12 to Figure 6.21. Spawning grounds of Group 1 receptors typically span much of the North Sea and English Channel, with some also extending into the Irish Sea (Coull et al.,1998). Therefore, the range of impact from concurrent piling activities relative to the broadscale distribution of the receptors, is considered a negligible magnitude of impacts. |
| Natural England (2024) S42 Consultation | Behavioural Impacts of Group 3 Receptors – Magnitude of Impact We disagree with the assessment of magnitude of impact as low. DeJong et al (2020) has documented the opposite, see https://link.springer.com/article/10.1007/s 11160-020-09598-9. Disturbances during spawning (such as from noise) may hamper a larger proportion of the population than during other times of the year. Fish are also more likely to be more vulnerable to | The Applicant confirms that a comprehensive assessment of the potential for behavioural effects from underwater noise on spawning herring has been undertaken and is detailed in Section 6.11 Impact 1, 6.12 Impact 8, and 6.13 Impact 17. The conclusions of the assessments are summarised in Table 6.44, and any additional mitigations proposed are detailed in Section 6.10. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | additional stressors as body condition of the fish during spawning is often poor. 'For many fish species, the spawning period may be highly sensitive to impacts from noise if individuals gather in dense, localized spawning aggregations (Colin et al. 2003). A disturbance during spawning may thus hamper a much larger fraction of the population compared to other periods of the year. Additionally, during this critical period, fish may also be most vulnerable to external stressors (Pörtner and Farrel 2008), because fish are often in their poorest body condition during the spawning period (Holst 2004; Rose et al. 2008).<br><br>We are concerned that disturbances during spawning (e.g. due to underwater noise) may have a significant impact on behavioural effects of spawning herring. This should be further considered and assessed in the submitted ES, with mitigation brought forward to address any significant impacts identified. | |
| Natural England (2024) S42 Consultation | VE is a significantly larger development than those projects referred to here, with turbines of up to 420m and a diameter of up to 15m. The hammer energy of up to 7,000 kJ is predicted to install the large monopiles which is significantly higher than the energy level reached in the identified sites. The duration of piling is longer too – with 7.5 hours required per monopile for VE. This will create significantly more noise impact during construction | The Applicant acknowledges that the proposed development is a larger development than those referred to in the cumulative assessment of underwater noise impacts on fish and shellfish receptors.<br><br>The Applicant confirms that the objective of the cumulative assessment is not to make comparisons across projects, but instead to review information and |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | and operation than the smaller sized OWF, and means that comparisons across smaller turbines are less valid.<br><br>The submitted ES should present information to demonstrate the comparison is a valid one, including any evidence that the predicted impacts from the projects referred to were validated by monitoring. | assessments, where available, as presented in the respective Environmental Statements of OWFs screened into the cumulative assessment, to determine the potential for cumulative effects on fish and shellfish receptors. |
| Natural England (2024) S42 Consultation | "The cumulative impact of underwater noise on fish and shellfish is predicted to be of regional spatial extent, medium term duration (i.e. cumulatively over approximately seven years), intermittent and reversible…The magnitude is, therefore, considered to be low." However, we would advise that a direct impact over seven years and on a regional scale is not of low magnitude.<br><br>We would advise that the magnitude of this impact would be greater than low – this assessment should be reconsidered for the submitted ES. | The assessment of cumulative impacts from underwater noise on sensitive receptors have been assessed in Section 6.14 Impact 24, and not significant effects on fish and shellfish receptors have been concluded.<br><br>The conclusions of the assessments are summarised in Table 6.44, and any additional mitigations proposed are detailed in Section 6.10. |
| Natural England (2024) S42 Consultation | Fish behavioural responses are likely to be different when exposed to a period of airgun firing compared to prolonged exposure to piling noise over a long period of time. The distribution patterns of fish within the area are also likely to change, with all seasons potentially impacted by piling activities. | This is noted by the Applicant, and the text in paragraph 6.14.30 has been amended accordingly to acknowledge that there are some uncertainties over the response of fish to intermittent piling over a prolonged period and the extent that behavioural reactions will cause a negative effect in individuals. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | The submitted ES should be clear about the limitations of the comparison made. | |
| Natural England (2024) S42 Consultation | “The impact of cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration is considered to be of low adverse magnitude, …maximum sensitivity… and significance is minor adverse.” It is unclear how an assessment of low adverse magnitude been made. We would advise that this assessment would result in a moderate significance when looking at Table 1.2 of the EIA methodology document.<br><br>We would advise that, without appropriate mitigation, the cumulative impacts to fish species (in particular, spawning herring and sandeel) due to the Project and relevant developments identified in the assessment, could result in a significance greater than minor adverse. Therefore, this assessment should be reconsidered in the submitted ES | The assessment of cumulative impacts from underwater noise on sensitive receptors have been assessed in Section 6.14 Impact 24, and not significant effects on fish and shellfish receptors have been concluded.<br><br>Significant effects from underwater noise on spawning Downs stock herring have been concluded from the project alone, and an additional mitigation measure in the form of a seasonal piling restriction has been proposed. This is summarised in Table 6.12. The Applicant is confident that with the implementation of this restriction during piling activities for VE, there will be no significant cumulative impacts from underwater noise. |
| Natural England (2024) S42 Consultation | Section 6.17.4 states that ‘Mortality, injury, behavioural impacts and auditory masking from underwater noise and vibration have the potential for a significance effect, in EIA terms, during the construction phase of development. In addition, significant effects also have the potential to occur on fish and shellfish receptors from cumulative mortality, injury, behavioural impacts and auditory masking | The Applicant confirms that a comprehensive assessment of the potential for impacts from underwater noise on fish and shellfish receptors has been undertaken and is detailed in Section 6.11 Impact 1, 6.12 Impact 8, and 6.13 Impact 17.The assessment of cumulative impacts from underwater noise on sensitive receptors have been assessed in Section 6.14, Impact 24. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | from underwater noise and vibration.' However, Table 6.33 states otherwise. If there is a potential for a significant effect then what is the mitigation proposed?<br><br>Please clarify the significance of the effect and whether mitigation is being applied to address the impact. | Significant effects from underwater noise on spawning Downs stock herring have been concluded from the project alone, and an additional mitigation measure in the form of a seasonal piling restriction has been proposed. This is summarised in Table 6.12. |
| Natural England (2024) S42 Consultation | Underwater noise modelling.<br><br>We defer to Cefas regarding all aspects of underwater noise modelling due to their expertise in this matter. | This is noted by the applicant. |
| Natural England (2024) S42 Consultation | Table 6.7 identifies "Downs stock spawning ground to the west of VE study area, and a spawning ground in Blackwater Estuary, south off the nearshore section of the offshore ECC.," and "High intensity herring nursery ground overlaps the nearshore section of the offshore ECC." This would suggest a potentially significant overlap between the Downs herring spawning habitat and the VE study area. However, in Section 6.7.18, it states that "Whilst these data indicate the potential for herring spawning habitats within the northern array area, and the mid-section of the ECC, there are also suitable spawning substrates present across the wider region, with areas of active spawning located within the English Channel (as indicated by IHLS data (ICES, 2007- 2020) (Figure | The Applicant has undertaken a herring spawning habitat suitability assessment to take into account the availability of suitable herring spawning habitat within the array areas and Offshore ECC in accordance with the MarineSpace (2013a and 2013b) methodologies Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report). This includes consideration of historic datasets, broadscale marine habitat mapping, and site-specific data.<br><br>A comprehensive assessment, as informed by the spawning habitat suitability assessment, of the potential impacts from the development on spawning herring is detailed in Sections 6.11, 6.12 and 6.13. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | 6.7)".Furthermore, Table 6.22 states that "the main spawning activity …is in the eastern English Channel and that spawning intensity on the Downs spawning grounds that overlap with VE are much less intense; long time series data confirm this has been the case since the 1970's (see – Collas et al., 2009 and Pawson, 1995). Firstly, these two references do not appear to have been included in the reference list. Secondly, they are also now quite old. Thirdly, there is some contradiction between the project-specific evidence and these older data with regards to the importance of the potential Down herring spawning area that overlaps the VE study area.<br><br>Owing to the lack of clarity regarding the importance of the VE study area as Downs herring spawning habitat and the potential for significant impacts, we advise that this should be further considered and assessed in the submitted ES, with mitigation identified and committed to, in order to reduce the potential impacts to an acceptable level. | The conclusions of the assessments are summarised in Table 6.44, and any additional mitigation proposed are detailed in Section 6.10. |
| May 2023<br><br>The National Federation of Fishermen's Organisations<br><br>S42 Consultation | We note with concern the response given in 2.1.3 to Natural England, regarding site specific surveys to provide data to advise the baseline characterisation. The argument that conducting these would provide only a 'temporal snapshot' of data specific to the species sampled, calls into question this entire assessment. The PEIR uses data from studies that | It is considered that there is very limited value in undertaking additional surveys for the purposes of informing the baseline or the subsequent assessment as such surveys are limited to those species that have been successfully sampled by the trawl at a distinct point in time; the only utility of such data being to confirm that the survey data aligns with the |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | are temporally and spatially limited, mostly to areas that are beyond the boundaries of the development area and makes assessments of impacts from such data. This too is only a 'temporarily snapshot' of data, specific to the studies cited and their spatial limits - a fundamental flaw in impact assessments. | wider regional data drawn from the existing datasets. It is also worth highlighting that should species not be recorded in a site specific survey, the outcome is not then to exclude consideration of these species from the characterisation or assessment process – rather, the baseline description and EIA draws upon (or defaults to) the wider literature, as this provides a more thorough, robust, and longer time series evidence base, which therefore ensures a more comprehensive and indeed precautionary baseline to be derived for the purposes of EIA. The species list (Table 6.9) derived from such data (Table 6.3) provides a broader list of receptors for assessment with greater certainty that all species present have been captured compared with a series of surveys. Additionally, it is also notable that site-specific surveys would be highly unlikely to identify any additional receptor species that are not already recorded in the extensive (both spatially and temporally) data that is available. |
| May 2023<br>The National Federation of Fishermen's Organisations<br>S42 Consultation | The reliance of offshore wind impact assessments on Coull *et al*., (1998) and Ellis *et al*., (2012) has been called into question in several of our responses to offshore developments. These data are over a decade old but seem to be given undue weight in assessing impacts on spawning and nursery grounds. | The Applicant confirms that the limitations of these datasets have been acknowledged in Section 6.6 of this chapter. The Coull *et al*., (1998) and Ellis *et al*., (2012) data sources are widely accepted across the offshore wind industry. Furthermore, to supplement these data sources, site specific PSA data have been used to inform the locations of suitable spawning |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | A more precautionary use of these data within the assessments would be appropriate. | substrates for demersal spawning receptors such as herring and sandeel and additional research publications and trawl survey data have also been reviewed to provide site-specific information (as summarised in Table 6.3 of this chapter, and detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report). |
| May 2023<br>The National Federation of Fishermen's Organisations<br>S42 Consultation | Section 2.4.9 states: "Despite the data limitations detailed within this section of the report, the data as detailed in Table 2.2 provides a robust and sufficient evidence base to inform the fish and shellfish baseline characterisation and underpin the assessment." We cannot agree. Site-specific and contemporary data to support such a sweeping statement is minimal. | The Applicant considers the data available from existing literature and relevant surveys provide an appropriate evidence base (both spatially and temporally) for fish and shellfish populations within the study area. The data sources utilised to inform the fish and shellfish baseline and the assessment are detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and are summarised in Table 6.3 of this chapter. Furthermore, VE confirms that the fish and shellfish baseline has been deemed sufficient for the purpose of EIA by the MMO, Natural England and Cefas. |
| May 2023<br>The National Federation of Fishermen's Organisations<br>S42 Consultation | Data was analysed from monitoring projects of other OWF developments, however the methodology used for these monitoring projects (e.g. otter trawl) is incorrect for sampling receptors that the data have been used to assess (e.g. shellfish). This incorrect use of data, from inappropriate methodologies, should be accounted for when assessing impacts to receptors. Acknowledging the limitations in the data | Data from monitoring projects of other offshore windfarm developments have been used purely as an indication of the presence of species across the region. It is also worth highlighting that should species not be recorded in the surveys; the outcome is not then to exclude consideration of these species from the characterisation of the baseline. The species list derived from such data (Table 6.9) provides a |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | but ignoring them – and treating them instead as conclusive evidence – misinforms the assessment of the impacts. This occurs throughout the chapter and brings into question the validity of the impact assessments. | broader list of receptors for assessment with greater certainty that all species present have been captured. |
| May 2023<br>Natural England<br>S42 Consultation | Natural England advise that there is a need for additional consideration of impacts to prey availability for SPA/SAC species, particularly during construction and in-combination. Natural England advise that the impact assessment for herring (in particular Downs herring), as an important prey species, should be revisited following additional assessment of their habitat area. | In accordance with advice from Natural England, the Applicant has undertaken a comprehensive assessment for important prey species of SPA and SAC features (such as, herring and sandeel) in Sections 6.11, 6.12, 6.13 and 6.14. This has been informed by a spawning habitat suitability assessment for herring and sandeel (see Section 6.7).<br>Potential impacts from the loss of prey species availability on SPA and SAC features, have been assessed in Volume 6, Part 2, Chapter 4: Offshore Ornithology and Volume 6, Part 2, Chapter 7: Marine Mammal Ecology. |
| May 2023<br>MMO<br>S42 Consultation | The MMO note the methodology used to determine the maximum extent of impacts utilising the ZoI. The MMO consider that the applicant has provided a sufficiently detailed description of the ecology of relevant fish receptors which have been identified based on their potential importance or sensitivity. The MMO agree that the receptors identified and in | This is welcomed by the Applicant. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | general their ecology and groupings appear appropriate. | |
| May 2023<br>MMO<br>S42 Consultation | The MMO note that the suitability assessment for Herring and Sandeel, plus the classification in accordance with Latto *et al*., 2013 and Reach *et al*., 2013 for preferred spawning habitats. The MMO consider these methods are a suitable way to infer preferred herring and sandeel habitats in both the regional and development area. | This is welcomed by the Applicant. |
| May 2023<br>MMO<br>S42 Consultation | The MMO recommends that the Applicant corrects the spawning season for herring in Table 6.8 in the Fish and Shellfish Ecology document. The Applicant has stated the spawning period for the Banks/Dogger herring population (August –October inclusive) rather than the Downs population which spawn between November to January (inclusive). This error however is not repeated throughout the document as in Table 6.22 the correct spawning time is stated. It should also be noted that the Thames/Blackwater herring, despite their location in Southeast England are a spring spawning stock. | The Applicant thanks the MMO for identifying this inconsistency and confirms that the amendments have been made to this chapter (See Table 6.8 for a summary of the spawning periods, including the amended Downs herring stock spawning period) and to Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. |
| May 2023<br>MMO<br>S42 Consultation | The MMO note that Applicant has quantified the impacts to spawning grounds and habitat as a percentage of area affected throughout the report (e.g. Tables 6.23-6.28 in the fish ecology chapter). The MMO do not support the calculation of total | The Applicant agrees with the points raised by the MMO with regards to the interchangeable nature of spawning and nursery ground extents. The spawning and nursery grounds and spawning seasons are defined by Ellis *et al*., (2012) and Coull *et al*., (1998). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | spawning habitat, as this approach can over- or underrepresent spawning grounds and is solely based on substrate suitability.<br><br>The MMO have provided a summary of the reasons below why we do not support the calculation of total spawning habitat:<br><br>(i) Spawning areas can change over time or become recolonised.<br><br>(ii) Whilst spawning and nursery ground maps are used to provide the most recent and appropriate information to identify spawning areas, they do not fully define/consider/identify the following:<br><br>• All potential areas of spawning,<br><br>• Any habituation that may occur i.e., identify areas where higher densities of spawning are present,<br><br>• Specific substrate requirements e.g., substrates which are most suitable within the wider broadscale sediments,<br><br>• More suitable topography e.g., ridges/edges of sandbanks where sandeel may spawn or furrows where herring may spawn,<br><br>• Environmental factors that may influence spawning intensity such as temperature, oxygenation, natural disturbance, anthropogenic disturbance etc., | The extents of the grounds and the durations of spawning periods are considered highly precautionary, on the basis that Coull *et al*., (1998) specifically states that the spawning and nursery grounds should be seen as representing the widest known distribution given current knowledge and should not be seen as rigid. This is also the case with the duration of spawning seasons, with the seasons tabulated in Coull *et al*., (1998) described as the generally accepted maximum duration of spawning. Therefore, VE deems that quantifying the percentage overlap of spawning grounds and the percentage temporal interaction with spawning periods is suitably precautionary for the assessment (see Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report for a description of the fish and shellfish ecology baseline, and Section 6.7 for a summary of the existing environment). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | • Calculations of specific spawning areas are based on peak spawning times i.e., the number of days of a spawning period rather than considering the entire spawning season.<br>The MMO would expect the Applicant to acknowledge the overlap with the spawning and/or nursery grounds, however, quantifying the impacts based on percentage overlap is not appropriate due the reasons described in (i) and (ii). | |
| May 2023<br>MMO<br>S42 Consultation | The MMO would not anticipate albacore tuna (*Thunnus alalunga*) to be a significant species to be scoped into an assessment in the southern North Sea, as this does not normally form part of their distribution. Bluefin tuna (Thunnus thynnus), however, have not been identified or included in the assessment and are common seasonal visitors to the North Sea (Horton *et al*., 2021). | The Applicant thanks the MMO for this input and confirms that Bluefin tuna have been incorporated into Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and the assessment as a VER (Table 6.9). |
| May 2023<br>MMO<br>S42 Consultation | MMO note that maps produced show that a large portion of the project site and ZOI can be considered suitable herring and sandeel habitat. The British Geological Society (BGS) and site-specific grab sample data show that much of the area would constitute preferred and marginal herring and sandeel habitat. The project site and ZOI also overlap the northern portion of the Downs herring spawning ground defined by Coull *et al*., (1998), where high | The Applicant notes the MMO's concerns about herring and sandeel habitats, and confirms that the technical baseline and assessment have been updated to take into account the availability of suitable herring and sandeel spawning habitat within the array areas and Offshore ECC in accordance with the MarineSpace (2013a and 2013b) methodologies as advised by the MMO, and site-specific geophysical survey data (see Volume 6, Part 5, Annex 6.1: Fish |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | intensity herring spawning occurs (Ellis *et al*., 2012). International Herring Larvae Survey (IHLS) data also show that the site and ZOI overlap areas of herring spawning activity as shown by herring larval abundance. Although larval abundance overlapping the site may appear moderate, this may be due to the available data and its presentation (see paragraphs 6.1.11 and 6.1.20 – 6.1.23 of this response). Based on the information provided the MMO consider that the site and ZOI are sensitive areas for both herring and sandeel. | and Shellfish Ecology Technical Baseline Report for the updated fish and shellfish baseline, and Section 6.7 for a summary of the existing environment, including the assessment of suitable spawning habitats using a heatmapping approach as defined by MarineSpace (2013a and 2013b)). |
| May 2023<br>MMO<br>S42 Consultation | MMO recommend that the Applicant provides a spawning/habitat site suitability 'heatmap' following the approach described by MarineSpace *et al*., (2013a and 2013b) for herring and sandeel respectively. The methods combine the data layers as noted in paragraph 6.1.4 of this response, for herring layers (i), (ii), (iv) and (v); and for sandeel (i), (ii) and (iv) and applies a confidence score to each data layer. This would provide a better visual representation of the spawning ground/habitat areas and the spatial extent of any impact with these areas. | The Applicant notes the MMOs concerns about herring and sandeel habitats, and confirms that the technical baseline and assessment have been updated to take into account the availability of suitable herring and sandeel spawning habitat within the array areas and Offshore ECC in accordance with the MarineSpace (2013a and 2013b) methodologies as advised by the MMO, and site-specific geophysical survey data (see Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report for the updated fish and shellfish baseline, and Section 6.7 for a summary of the existing environment, including the assessment of suitable spawning habitats using a heatmapping approach as defined by MarineSpace (2013a and 2013b)). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| May 2023<br>MMO<br>S42 Consultation | The MMO highlight the impacts and sources of UWN which have been assessed in this chapter. With regards to UXO, the MMO acknowledge that the Applicant will seek consent for UXO clearance under a separate Marine Licence (post-consent) and this will not be consented under the DCO. Therefore, only a high-level assessment has been provided at this stage which the MMO consider to be appropriate. The MMO would expect an assessment of impacts to fisheries and fish ecology arising from UXO clearance to be included in the supporting evidence at the time the Marine Licence application for this activity is submitted. | The Applicant confirms that an assessment of impacts to fisheries and fish ecology arising from UXO clearance will be included in the supporting evidence at the time the Marine Licence application for UXO clearance activities. |
| May 2023<br>MMO<br>S42 Consultation | The VERs have been grouped according to their hearing capabilities (see paragraph 6.1.5 of this response) and have been assessed as both stationary and fleeing receptors. In addition, both sequential and concurrent piling scenarios have been modelled. The MMO consider this to be appropriate, however, due to uncertainties in receptor responses to UWN only the impacts to stationary receptors will be reviewed. | This is noted by the Applicant. |
| May 2023<br>MMO<br>S42 Consultation | It is the MMO's opinion that it should also be noted that although the behavioural effects of UWN on fish receptors has been considered, no modelling has been carried out to ascertain the spatial extent of this. | The Applicant maintains that the 135dB threshold is overly precautionary, and that as stated by Popper *et al*., (2014) it is not appropriate to determine the potential for behavioural effects quantitively due to |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | The MMO recommend that the Applicant presents modelling for the received levels of single strike sound exposure levels (SELss) at the herring spawning ground/s (Downs and Thames/Blackwater herring spawning grounds) based on 135dB threshold in the final ES. The use of the 135dB is based on startle responses observed in sprat by Hawkins *et al*., (2014a). Sprat is considered a suitable proxy species for herring for the purpose of modelling likely behavioural responses in gravid herring at the spawning ground. The MMO accept that, as stated by the Applicant, this a conservative estimate for a behavioural response, however we advise a precautionary approach. The Applicant argues based on a study by Skaret *et al*., (2005) that herring are much less lightly to respond to sound when engaging in life history critical activities. Whilst the MMO do not completely disagree with this statement there are two factors that should be considered:<br><br>i) The study was based on vessel noise and not the sound generated from impact piling which may result in different behavioural responses.<br><br>ii) If herring do not respond to the sound produced during impact piling and continue to head to spawning grounds in or near the development, they may then suffer TTS, injury or mortality. | the range of behavioural responses, and external stimuli and life events that can influence them. However, notwithstanding this, VE has presented potential behavioural impact ranges as 5dB increments from the piling source and undertaken a literature review to inform the potential range and magnitude of effects on sensitive receptors (see Section 6.11, Impact 1 and Figure 6.22 and Figure 6.23).<br><br>The Downs herring stock migrates in a clockwise circuit in the North Sea, migrating from the northeast to the Downs spawning ground to the southeast, and then continuing in a northerly direction (Cushing, 2001). VE lies within the migration pathway for herring, however, is positioned on the northeastern return leg of the herring migration pathway. Therefore, it is not considered that piling would have any impacts on herring migration to the spawning grounds. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | iii) It should also be noted that the Downs herring migrate from south to north during their spawning season, moving from the English Channel up through the North Sea, therefore there may be the potential for piling noise at VE to act as an acoustic barrier to migration.<br><br>It is noted that impacts of UWN to all receptors including acoustically sensitive species such as herring and seahorse and other stationary receptors like sandeel have been assessed, with potential impacts ranging from negligible to moderate adverse, which are not significant in EIA terms. Whilst the MMO agree with this assessment for most receptors during the operational phase, we believe UWN generated by piling during construction could cause a significant impact to spawning herring and thus to the Downs herring population. | |
| May 2023<br><br>MMO<br><br>S42 Consultation | The MMO note that Table 6.22 of Chapter 6: Fish and Shellfish states that although the development and ZOI overlaps the Downs herring spawning grounds and suitable spawning habitat (see paragraph 6.1.10 of this response), the IHLS data indicate that spawning actually occurs in the eastern English Channel, with the spawning intensity of the Downs stock overlapping the ZOI being much less intense. The Applicant has referenced studies by 'Collas *et* | The Applicant has provided additional clarification in the chapter regarding the presentation of relative abundance of herring larvae within section 6.7.15. Individual years of IHLS surveys are also presented as heatmaps in Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps.<br><br>The Applicant has added the appropriate references to the references list. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | *al*., 2009 and Pawson, (1995) presenting this, however these studies have not been included by the Applicant in the reference list. The MMO disagree with this statement for the following reasons; the Southern North Sea and eastern English Channel (SNS) IHLS surveys are conducted as three separate sampling events; one in the 3rd quarter of each year undertaken by the Netherlands between 16-31 December, and two in the 1st quarter of each year; between 1-15 January undertaken by Germany, and between 16-31 January undertaken by the Netherlands. It is understood that Downs herring spawning activity in northern parts of the spawning grounds occurs later in the season compared to those grounds further south in the English Channel. Please see Annex 2 for examples of this taken from ICES (2014 and 2016) which demonstrate the variations in larvae abundance according to the periods in which surveys were carried out.<br><br>The MMO note that references have been included for studies showing long time series data demonstrating that herring have not spawned intensively in the western part of the English Channel since the 1970's. The MMO was unable to find these studies in the reference list of the Fish and Shellfish Ecology chapter (Chapter 6: Fish and Shellfish | |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | Ecology) to review and would welcome copies of these studies. | |
| May 2023<br>MMO<br>S42 Consultation | Based on the UWN modelling results and sensitivity of herring spawning habitat within the ZOI it is highly likely mitigation in the form of a temporal piling restriction during the Downs herring spawning season will be required, however, the MMO will be able to confirm this once the final ES is provided for review. The Downs spawning period is between November 1st and January 31st inclusive. However, the MMO believe there may be an opportunity for the temporal restriction to be refined based on the knowledge that spawning in this part of the Downs spawning ground occurs later in the season. However, any refinement in the duration of the restriction must be based on evidence. In order for the MMO to consider a shorter restriction than that of the full spawning season (November to January inclusive). | This is noted by the Applicant, and appropriate mitigation measures have been proposed in Table 6.12, as informed by the underwater noise assessment in Impact 1, Section 6.11. |
| May 2023<br>MMO<br>S42 Consultation | The MMO provide more info on modelling, they note modelling of the 135dB noise threshold is required to establish the range of impact for behavioural responses in herring to obtain the full range over which herring behaviour could be impacted. This can then be compared to individual years of IHLS larval survey data between the periods January 1st-15th and January 16th-31st in order to determine the highest larval densities which occur in the ZOI, and | The Applicant maintains that the 135dB threshold is overly precautionary, and that as stated by Popper *et al.*, (2014) it is not appropriate to determine the potential for behavioural effects quantitively due to the range of behavioural responses, and external stimuli and life events that can influence them. However, notwithstanding this, VE has presented potential behavioural impact ranges as 5dB increments from the piling source and undertaken a |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | where there are 'hotspots' of continuously high larval densities in any year. Once the peak of high larval densities has been determined, a back-calculation from this period can be made to ascertain the approximate weeks when the herring will be aggregating, spawning and laying their eggs. | literature review to inform the potential range and magnitude of effects on sensitive receptors. VE notes the MMO's suggestion of utilising back calculations to identify the peak spawning period of the Downs herring stock. The temporal piling restriction proposed by the Applicant is summarised in Table 6.12, and the evidence to inform the back-calculations used to inform the peak spawning period are detailed in the Herring Seasonal Restriction Note. |
| May 2023<br>MMO<br>S42 Consultation | The MMO note that temporary increases in SSC will likely impact the spawning grounds of herring and sandeel and other species in the vicinity of the works. Sandeel and their eggs are not considered particularly sensitive to elevated SSC or smothering due to the naturally high SSC and deposition in their high energy natural environment. Herring are more sensitive where benthic eggs may be smothered, reducing oxygen and impacting egg and larval development. Adult herring are considered less sensitive due to their mobility although as stated previously in paragraph 6.1.18 of this response, it is not clear if they will be able to move away from the source of impact if migrating or spawning. It is stated that the plume will overlap 7.68% and 0.5% of the Downs and Blackwater spawning areas respectively, however as discussed in paragraph 6.1.7 this is not an appropriate way to quantify the impacts to herring | The Applicant has incorporated additional information from the physical processes modelling to inform the assessment, with particular regard to the distribution, settlement and resuspension of fine sediments during the construction phase. Furthermore, the assessment has been updated take into account the availability of suitable herring and sandeel spawning habitat within the array areas in accordance with the MarineSpace (2013a and 2013b) methodologies (see Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report for the fish and shellfish ecology baseline, and Section 6.7 for a summary of the existing environment, including the assessment of suitable spawning habitats using a heatmapping approach as defined by MarineSpace (2013a and 2013b)). The assessment of the potential impacts to herring and sandeel have been updated accordingly (see Impact 2, Section 6.11). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | (this has also been repeated when assessing other impacts). Owing to the overlap of the project array areas with the Downs herring spawning ground (as depicted in drawing no. 6.7 of Chapter 6: Fish and Shellfish Ecology), the MMO have major concerns regarding the impacts arising from increased SSC and subsequent deposition of sediment on gravid herring and their eggs and larvae as a result of construction activities which cause disturbance to the spawning habitat and therefore the MMO do not support the Applicant's conclusion that impacts to Downs herring will be minor adverse. | The conclusions of the assessments are summarised in Table 6.44, and any additional mitigations proposed are detailed in Section 6.10. |
| May 2023<br>MMO<br>S42 Consultation | It is noted that the Applicant has assessed the impacts from increases in SSC and deposition to other fish receptors as minor adverse (not significant) and the MMO generally agree with this assessment. The MMO also agree that given the distance between the project ZOI and the Thames/Blackwater herring spawning grounds at the mouth of the Blackwater estuary in Essex and Herne Bay in Kent, that impacts to this population will be minor adverse. | This is welcomed by the Applicant. |
| May 2023<br>MMO<br>S42 Consultation | Seabed disturbances leading to the release of sediment contaminants: The assessment of impacts to fish receptors has been concluded as minor adverse (not significant) during construction and decommissioning activities. This impact has been scoped out for the operational phase and although | This is welcomed by the Applicant. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | the exact reason has not been stated the MMO assume this is due the small amount of SSC expected to be generated during the operational phase and the long time period over which this will happen. The MMO agree with the Applicant's decision to scope out the release of sediment contaminants from further assessment. | |
| May 2023<br>MMO<br>S42 Consultation | Impacts on fishing pressure due to displacement: Fishing restrictions (both spatial and temporal) during the construction, operation and decommissioning phased of the array and ECC may displace fishing effort and concentrate this in other areas. The scale of this is expected to be small and should be monitored compensated by fisheries managers. The Applicant has assessed this impact to fish receptors as negligible and the MMO agree with this assessment. | This is welcomed by the Applicant. |
| May 2023<br>MMO<br>S42 Consultation | Direct damage and disturbance: The MMO acknowledges that there are potential impacts to spawning herring and sandeel due to the location of the array and ECC which overlaps herring and sandeel spawning grounds. It is noted that the Applicant has assessed the impacts to fish receptors as negligible to minor adverse (not significant) with the latter for sandeel and herring. This is due to the relatively small impacted area, in the context of the spawning and nursery grounds, and therefore it is | This is welcomed by the Applicant. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | unlikely to cause impacts at a population level. The MMO generally agree with this assessment, with the exception of Downs herring during their spawning season, as noted below in paragraph 6.1.30. | |
| May 2023<br>MMO<br>S42 Consultation | As raised in paragraph 6.1.25 of this response, the MMO have major concerns regarding the impacts arising from direct damage and disturbance to seabed sediments within the array areas which serve as herring spawning habitat and do not support the Applicant's conclusion that impacts to Downs herring resulting from direct damage and disturbance will be minor adverse. The MMO note that the Applicant has again attempted to quantify the impacts to the Downs spawning ground as approximately 1.9% of the habitat, which the MMO do not support. | The Applicant confirms that the assessment has been updated to take into account the availability of suitable herring and sandeel spawning habitat within the array area and ECC in accordance with the MarineSpace (2013) methodology (see Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report for the fish and shellfish ecology baseline, and Section 6.7 for a summary of the existing environment, including the assessment of suitable spawning habitats using a heatmapping approach as defined by MarineSpace (2013a and 2013b)), and site-specific geophysical survey data. The conclusions of the assessment have been revised accordingly to determine the potential effects of direct damage and disturbance to seabed sediments within the array areas (See Impact 5, Section 6.11). |
| May 2023<br>MMO<br>S42 Consultation | Accidental Pollution Events: The likelihood of an incident will also be reduced by the implementation of an Outline Project Environmental Management Plan (PEMP) and Outline Marine Pollution Contingency Plan (MPCP). The MMO note that the Applicant has assessed the impact to fish receptors as minor | This is welcomed by the Applicant. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | adverse (not significant), the MMO agree with this assessment. | |
| May 2023<br>MMO<br>S42 Consultation | Temporary habitat loss/ disturbance: The MMO note that this impact is expected to occur during the construction, operational and decommissioning phases and appears approximately the same as 'direct damage and disturbance'. It is also stated to encompass the same area and impact pathways. The Applicant has again assessed this as negligible to minor adverse (not significant), for all fish species.<br>The MMO do not support the assessment conclusion for Temporary Habit Loss/Physical Disturbance of minor adverse for Downs herring due to the overlap with the Downs herring spawning ground, particularly, in respect of the southern array which shows a clear overlap with the spawning grounds mapped by Coull *et al*., (1988) and consistent presence of herring larvae through the IHLS data.<br>The introduction of hard substrate into a generally soft substrate environment will have a negative impact on species such as herring and sandeel which have specific substrate requirements. The MMO note that the Applicant considers that the area to be 'lost' is small in the context of the available habitat in the area, therefore it is unlikely to have significant impacts at a population level. The Applicant has | The Applicant confirms that the assessment has been updated to take into account the availability of suitable herring spawning habitat within the array area in accordance with the MarineSpace (2013) methodology, and site-specific geophysical survey data. The conclusions of the assessment have therefore been revised accordingly to determine the potential effects of long-term/permanent loss of spawning habitat (see Impact 11, Section 6.12). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
| --- | --- | --- |
| | assessed this impact as negligible to minor adverse for fish receptors (not significant).<br><br>At this stage the MMO do not support the conclusion of minor adverse impacts to Downs herring. As noted previously in this response, the MMO require a more accurate habitat assessment of potential spawning habitat using a combination of sediment data and larval data following MarineSpace (2013a) in order to ascertain the availability of suitable spawning habitat in the array areas, and thus the implications of long-term/permanent loss of spawning habitat. | |
| May 2023<br><br>MMO<br><br>S42 Consultation | Increased hard substrate and structural complexity: This impact has only been considered for the operational phase and is broadly similar in scope and impacts to 'long-term loss of habitat'. The MMO note that this has again assessed this as negligible to minor adverse (not significant). The MMO agree with this assessment, however, we still have concerns regarding impacts to Downs herring as this also applies to the impact of increased hard substrate and structural complexity which effectively reduces the availability of gravel sediments as spawning habitat (see the above comment, paragraph 6.1.36). | This is noted by the Applicant; the main focus of the assessment of potential impacts from increased hard substrate and structural complexity relates to impacts from changes to the biodiversity of the site from long term or permanent changes in substrates. Potential impacts from loss of suitable herring spawning habitat are assessed under Impact 11 in Section 6.12.<br><br>The Applicant also confirms that the assessment has been updated to take into account the availability of suitable herring spawning habitat within the array area in accordance with the MarineSpace (2013a) methodology. The conclusions of the assessment have therefore been revised accordingly to determine the potential effects of the loss of herring spawning habitat (Table 6.35). |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| May 2023<br>MMO<br>S42 Consultation | Electromagnetic Fields (EMF) effects arising from cables: EMF are produced as a result of electricity passing through cables and may lead to attraction or repulsion in receptors that can sense the fields such as elasmobranchs and some other fish species. EMF diminishes with distance from the source therefore burying and the placement of scour protection will increase the distance from the cable to sensitive fish receptors. Maximum burial depth of the inter array and ECC are stated as 3.5m and a Cable Specification and Installation Plan (CSIP) will be developed to set out an appropriate cable burial depth.<br>The MMO would like to highlight that, in accordance with the National Policy Statement for Renewable Energy Infrastructure (EN-3) (Dept. of Energy & Climate Change, 2011), where possible, the Applicant should ensure a minimum cable burial depth of no less than 1.5m (subject to local geology and obstructing objects) in order to mitigate the impacts of EMF on fish receptors. | This is noted by the Applicant. A target burial depth will be informed by post-consent Outline Cable Burial Risk Assessment (Volume 9, Report 9), and the CSIP (in accordance with the outline CSIP, Volume 9, Report 12) which will also identify what (if any) cable protection is required to address both technical and ecological requirements. |
| May 2023<br>MMO<br>S42 Consultation | Shellfish Ecology - The MMO is content that the applicant has identified commercial shellfish species present at the proposed site. The MMO acknowledge that the specific commercial value of cockles and whelk fisheries in the area have been highlighted. | This is welcomed by the Applicant |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| May 2023<br>MMO<br>S42 Consultation | Shellfish Ecology -The MMO is satisfied with the scope of the evidence base proposed and note that there is expected to be 4 years between the assessment and work commencing. The MMO would like to highlight that we only consider the baseline to provide an accurate representation for up to 5 years after the assessment, when no significant changes having occurred. Should the period between application and the commencement of work be greater than 5 years, or significant changes have occurred at the site, we would expect to see updated baseline conditions. | This is welcomed by the Applicant |
| May 2023<br>MMO<br>S42 Consultation | Shellfish Ecology - Although no mitigation measures have been proposed in relation to shellfish, the MMO note that the project has mitigation which is in line with good practices. | This is welcomed by the Applicant |
| May 2023<br>MMO<br>S42 Consultation | Shellfish Ecology - The MMO is concerned with the assumption that cockles are quite able to bury. The MMO consider that this statement is too simplistic and would prefer this to be revised to highlight that they are able to bury, however, the potential to do so is dependent on the suitability of the sediment type and the stress level of the individual. | This is noted by the Applicant, and the assessment of potential impacts to cockle has been updated accordingly (Sections 6.11, 6.12, 6.13 and 6.14). |
| May 2023<br>MMO | MMO note there are minor technical or presentational comments that affect the overall confidence in the | This is noted by the Applicant, and the fish and shellfish ecology chapter has been amended accordingly. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| S42 Consultation | conclusions (please see paragraphs 6.1.5-6.1.7, 6.1.9, 6.1.19 and 6.1.20).<br><br>- Wrong reference - Coull *et al*., (2010), this should be Coull *et al*., (1998) see Table 6.24 of documents reviewed 5(vi).<br><br>- Wrong refence – Ellis *et al*., (2010), this should be Ellis *et al*., (2012) see section 6.7.7 - 6.7.8 in documents reviewed 5(vi).<br><br>- Figure numbers and legends are not visible on large maps in documents reviewed 5(vi and vii).<br><br>- 'North seahorse mackerel' in section 8.7.47 in review document 5(vii).<br><br>- Section 6.10.102 of documents reviewed 5(vi) it states a minor adverse effect is significant in EIA terms.<br><br>- Table 6.33 says 'Impact 5: Direct damage (e.g. crushing) and disturbance to demersal and pelagic fish and shellfish species arising from shellfish activities' instead of construction activities in reviewed document 5(vi).<br><br>- Reference Reach *et al*., (2013) appears twice in reference list in documents reviewed 5(vi).<br><br>- Table 1.71 although it states for 'fleeing' and 'stationary' in the legend it is not clear in the table | |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | which each impact area refers to, see review document 5(ix). | |
| May 2023<br>MMO<br>S42 Consultation | The Applicant has utilised a desk-based assessment to characterise and assess fish and fisheries receptors. For fish receptors this included a broad combination of datasets including pre- and post-construction surveys from previous OWF developments, in addition to a variety of national and international monitoring programs and reports. The data sources used by the Applicant for the assessment are generally appropriate. | This is welcomed by the Applicant. |
| May 2023<br>MMO<br>S42 consultation | The MMO note that for fisheries receptors the Applicant only appears to have included and assessed impacts during the construction phase of the project. The Applicant has assessed the cumulative impacts as minor adverse for all the potential cumulative impacts to fish receptors. Whilst the MMO agree with this statement with respect to temporary and long-term habit loss, UWN and increased SSC have the potential to cause significant adverse impacts on spawning herring and sandeel (see paragraphs 6.1.16 – 6.1.22 and 6.1.23 – 6.1.25 for details). Therefore, the cumulative impacts to spawning herring and sandeel due to VE and the developments identified by the Applicant in the vicinity have the potential to be significant if appropriate mitigation is not implemented. | VE acknowledges these concerns about cumulative impacts on demersal spawning receptors, from increased SSC and underwater noise, and confirms that the cumulative assessment has been revised to take into account the availability of suitable herring and sandeel spawning habitat within the array areas and ECC in accordance with the MarineSpace (2013) methodology and the assessments updated accordingly. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| May 2023<br>MMO<br>S42 Consultation | It is not clear if the cumulative impacts have been assessed for the operational or decommissioning phases for fish receptors. It should be noted that for the general assessment, long-term habitat loss has been scoped out for the construction phase but is included for this phase in the cumulative assessment. However, in the description of temporary habitat loss in the cumulative assessment it does then discuss impacts in the operational phase, but this is not discussed in the context of long-term habitat loss. There is also no mention in the cumulative assessment of other potential impacts assessed in the general assessment (see Annex 2). The MMO accept that a cumulative impact assessment for the decommissioning phase is not appropriate at this stage due to the level of uncertainty of what developments/works will be taking place in the future. The reasons for the inclusions/exclusions should however be more clearly justified within the PEIR. | This is noted by the Applicant, and additional justification for the exclusion of impacts assessed within the cumulative assessment have been provided in Section 6.14 of this chapter. |
| May 2023<br>MMO<br>S42 Consultation | The Applicant has assessed long-term habitat loss as an impact during the construction phase for the cumulative assessment, however this has been scoped out of the main assessment of VE and only included for the operational phase. In addition, when assessing the cumulative impacts, the Applicant has evaluated temporary habitat loss. The Applicant should clarify this inclusion in the cumulative | This is noted by the Applicant, and additional justification for the inclusions or exclusions of impacts assessed within the cumulative assessment have been provided within Section 6.14 of this chapter. |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | assessment if it is not to be included for the main assessment of VE alone. | |
| May 2023<br>MMO<br>S42 Consultation | The MMO do not support the calculation of total spawning habitat presented in the Tables 6.23 -6.28 in, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology - fish ecology chapter. The MMO considers that you should acknowledge the overlap with the spawning and/or nursery grounds but quantifying the impacts based on percentage overlap is not appropriate due the reasons described in (i) and (ii) in paragraph 6.1.7. | VE agrees with the points raised by the MMO with regards to the interchangeable nature of spawning and nursery ground extents. The spawning and nursery grounds and spawning seasons are defined by Ellis *et al.,* (2012) and Coull *et al*., (1998). The extents of the grounds and the durations of spawning periods are considered highly precautionary, on the basis that Coull *et al*., (1998) specifically states that the spawning and nursery grounds should be seen as representing the widest known distribution given current knowledge and should not be seen as rigid. This is also the case with the duration of spawning seasons, with the seasons tabulated in Coull *et al.*, (1998) described as the generally accepted maximum duration of spawning. Therefore, VE deems that quantifying the percentage overlap of spawning grounds and the percentage temporal interaction with spawning periods is suitably precautionary for the assessment. |
| May 2023<br>MMO<br>S42 Consultation | The MMO believe that additional modelling of the behavioural effects on UWN on fish receptors should be carried out to ascertain the spatial extent of this, see paragraph 6.1.18. | VE maintains that the 135 dB threshold is overly precautionary, and that as stated by Popper et al., (2014) it is not appropriate to determine the potential for behavioural effects quantitively due to the range of behavioural responses, and external stimuli and life events that can influence them. However |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | notwithstanding this, VE has presented potential behavioural impact ranges as 5 dB increments from the piling source, and undertaken a literature review to inform the potential range and magnitude of effects on sensitive receptors (see Impact 1, Section 6.11. |
| May 2023<br>MMO<br>S42 Consultation | Mitigation in the form of a temporal piling restriction during the Downs herring spawning season will likely be required due to the UWN modelling results and sensitivity of herring spawning habitat within the ZOI, see paragraph 6.1.22. | This is noted by the Applicant, and appropriate mitigation has been proposed in Table 6.12, and detailed in Section 6.11 of the chapter. |
| May 2023<br>MMO<br>S42 Consultation | The MMO have major concerns regarding the impacts arising from increased SSC and subsequent deposition of sediment on gravid herring and their eggs and larvae as a result of construction activities which cause disturbance to the spawning habitat and therefore MMO do not support the conclusion that impacts to Downs herring will be minor adverse, see paragraph 6.1.25. | VE has incorporated additional information from the physical processes modelling to inform the assessment, with particular regard to the distribution, settlement and resuspension of fine sediments during the construction phase. The assessment of the potential impacts to herring has been updated accordingly (See Impact 2, Section 6.11). |
| May 2023<br>MMO<br>S42 Consultation | As per paragraph 6.1.25, the MMO have major concerns regarding the impacts arising from direct damage and disturbance to seabed sediments within the array areas which serve as herring spawning habitat and do not support the conclusion that impacts to Downs herring resulting from direct damage and disturbance will be minor adverse, see paragraph 6.1.30. | VE confirms that the assessment has been updated to take into account the availability of suitable herring spawning habitat within the array area in accordance with the MarineSpace (2013) methodology, and site-specific geophysical survey data. The conclusions of the assessment have been revised accordingly to determine the potential effects of direct damage and |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| | | disturbance to seabed sediments within the array areas (see Impact 3, Section 6.11). |
| May 2023<br>MMO<br>S42 Consultation | The MMO do not support the assessment conclusion for Temporary Habit Loss/Physical Disturbance of minor adverse for Downs herring due to the overlap with the Downs herring spawning ground, particularly, in respect of the southern array which shows a clear overlap with the spawning grounds mapped by Coull *et al*., (1988) and consistent presence of herring larvae through the IHLS data, see paragraph 6.1.34. | VE confirms that the assessment has been updated to take into account the availability of suitable herring spawning habitat within the array area in accordance with the MarineSpace (2013) methodology, and site-specific geophysical survey data. The conclusions of the assessment have been revised accordingly to determine the potential effects of temporary habitat loss/disturbance to herring spawning habitats within the array areas (See Impact 7, Section 6.11). |
| May 2023<br>MMO<br>S42 Consultation | The MMO consider that unless all parts of the development including all scour protection are to be removed when decommissioning occurs we recommend changing 'long-term loss of habitat' to 'permanent habitat loss' as this reflects the fact that some parts of the development will remain past the decommissioning phase. However, the MMO is content with the decision to scope out 'long-term/permanent loss of habitat' for the construction phase of the development. However, unless all infrastructure is to be removed at decommissioning, this impact should be scoped in for this phase of development, see paragraph 6.1.36. | Whilst the base case is that all infrastructure will be removed during decommissioning, VE notes that this is subject to environmental assessment at the time and has therefore changed the long-term loss of habitat impact, to 'long term or permanent loss of habitat', to reflects the potential for some parts of the development to remain past the decommissioning phase. |
| May 2023<br>MMO | At this stage, the MMO do not support the conclusion of minor adverse effect to Downs herring, see | VE confirms that the assessment has been updated to take into account the availability of suitable herring |

| Date and consultation phase/ type | Consultation and key issues raised | Section where comment addressed |
|---|---|---|
| S42 Consultation | paragraphs 6.1.4, 6.1.11 and 6.1.36. The MMO require a more accurate habitat assessment of potential spawning habitat using a combination of sediment data and larval data following MarineSpace (2013a). | spawning habitat within the array area in accordance with the MarineSpace (2013) methodology, and site-specific geophysical survey data. The conclusions of the assessment will therefore be revised accordingly with regards to potential effects on spawning herring. |

## 6.4 SCOPE AND METHODOLOGY

### SCOPE OF THE ASSESSMENT

#### IMPACTS SCOPED IN FOR ASSESSMENT

6.4.1 The following impacts have been scoped into this assessment:

- Construction Phase:
  - Impact 1: Mortality, injury, behavioural impacts, and auditory masking arising from noise and vibration;
  - Impact 2: Temporary increases in SSC and sediment deposition;
  - Impact 3: Direct and indirect seabed disturbances leading to the release of sediment contaminants;
  - Impact 4: Impacts on fishing pressure due to displacement;
  - Impact 5: Direct damage (e.g., crushing) and disturbance from construction operations including foundation installation and cable laying operations;
  - Impact 6: Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors; and
  - Impact 7: Temporary habitat loss/disturbance from construction operations including foundation installation and cable laying operations.
- Operation and Maintenance Phase:
  - Impact 8: Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration;
  - Impact 9: Temporary increases in SSC and sediment deposition arising from operation and maintenance activities;
  - Impact 10: Impacts on fishing pressure due to displacement;
  - Impact 11: Long-term or permanent loss of habitat due to the presence of WTGs foundations, scour protection and cable protection;
  - Impacts 12: Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection;
  - Impact 13: EMF effects arising from cables during the operational phase;
  - Impact 14: Direct damage (e.g., crushing) and disturbance to mobile, demersal and pelagic fish and shellfish receptors from operation and maintenance activities;
  - Impact 15: Accidental pollution events during the operation and maintenance phase resulting in potential effects on fish and shellfish receptors; and
  - Impact 16: Temporary habitat loss/ physical disturbance.

- Decommissioning Phase:
  - Impact 17: Mortality, injury, behavioural impacts, and auditory masking arising from noise and vibration;
  - Impact 18: Temporary increases in SSC and sediment deposition;
  - Impact 19: Direct and indirect seabed disturbances leading to the release of sediment contaminants;
  - Impact 20: Impacts on fishing pressure due to displacement;
  - Impact 21: Direct damage (e.g., crushing) and disturbance to mobile, demersal and pelagic fish and shellfish receptors from decommissioning activities;
  - Impact 22: Accidental pollution events during the decommissioning phase resulting in potential effects on fish and shellfish receptors; and
  - Impact 23: Temporary habitat loss/disturbance.

### IMPACTS SCOPED OUT OF ASSESSMENT

6.4.2 On the basis of the baseline environment and the project description outlined in Volume 6, Part 2, Chapter 1: Offshore Project Description and in accordance with the Scoping Opinion (PINS, 2021), a number of impacts have been scoped out, these include:

- Construction and decommissioning:
  - Long-term loss of habitat due to the presence of WTGs foundations, scour protection and cable protection;
  - Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection; and
  - EMF effects arising from cables during the construction and decommissioning phases of development.
- Operation and maintenance:
  - Direct and indirect seabed disturbances leading to the release of sediment contaminants.

### STUDY AREA

6.4.3 The fish and shellfish ecology study area is dynamic, in that it varies according to the nature of the impact being studied. The study area is therefore defined by the furthest reaching Zone of Influence (ZoI). Based on experience from recent OWF projects, the largest ZoI relates to underwater noise from piling in the array areas. The exact extents over which noise effect thresholds will be reached has been determined through detailed underwater noise modelling (see Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report), based on the maximum design scenario as relates to the greatest spatial, and greatest temporal effects. The maximum impact range from underwater noise will be up to 39 km from the array areas. However, to ensure a precautionary approach, the ZoI for underwater noise and therefore the study area has been informed by impact ranges for the 186 dB re 1 μPa$^2$s Sound Exposure Level (SEL) for recent UK OWF applications (Awel y Môr OWF, Sheringham Shoal and Dudgeon OWF Extension Projects, Hornsea Four OWF and Norfolk Boreas OWF), therefore a 50 km ZoI for underwater noise impacts is therefore deemed appropriate for VE.

6.4.4 Piling will not be undertaken within the VE offshore ECC, and therefore a secondary study area is also considered appropriate (as the underwater noise ZoI does not subsume the entire offshore ECC), to account for potential impacts on fish and shellfish receptors from activities within the offshore ECC. The largest ZoI from activities within the offshore ECC would result from increased SSCs and associated sediment deposition and smothering from foundation and cable installation works and seabed preparation works. The 'Sedimentary ZoI' is based on the mean spring tidal excursion buffer of the site (a maximum excursion of 22.5 km), which represents the expected maximum distance that suspended sediments may be transported on a mean spring tide in a flood and/or ebb direction (although the majority of suspended sediment are expected to be deposited much closer to the disturbance activity). It should be noted that the underwater noise ZoI largely subsumes the Sedimentary ZoI, therefore for the purposes of the baseline characterisation of the existing environment the two ZoIs have been merged to create a study area representing the largest potential ZoI. The study area is shown in Figure 6.2.

## DATA SOURCES

6.4.5 A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the fish study area for VE. Information was sought on fish and shellfish ecology in general and on spawning and nursery activity. The baseline characterisation utilises a broad combination of datasets and provides a robust temporal analysis and validation of regional monitoring datasets. In addition, the fish and shellfish ecology characterisation will be informed through site-specific benthic ecology surveys to be undertaken across the array areas and within the offshore ECC. These surveys include particle size analysis (PSA) of sediment samples and data collected from these surveys will be used to inform on spawning habitat suitability for demersal spawning fish such as spawning herring and sandeel.

6.4.6 The data available from existing literature and relevant surveys provide an appropriate evidence base for fish and shellfish populations within the VE Study Area, sufficient for the purposes of EIA and it is intended that these are utilised to characterise the fish and shellfish receptors in the vicinity of the VE study area. On the basis that sufficient information exists to enable a robust characterisation of the receiving environment, including identification of relevant valued fish and shellfish receptors, additional site-specific surveys have not been proposed to be undertaken.

6.4.7 Table 6.3 details the data sources utilised in the baseline characterisation. Full details on the data sources and the utilisation of each data source are provided in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.

**Table 6.3: Data sources used to inform fish and shellfish baseline characterisation and assessment**

| Data Source | Data Summary | Spatial coverage | Temporal coverage |
|---|---|---|---|
| Environmental Statements, and pre- and post-construction monitoring reports from other OWF developments within the defined study area:<br>Gunfleet Sands OWF;<br>Galloper OWF;<br>Greater Gabbard OWF; and<br>London Array OWF. | Site specific fish and shellfish surveys for OWF Projects in the area.<br>Used to provide a fish and shellfish ecology characterisation taken from previous OWF project surveys of the area. | Specific to OWF project locations. | 2007-2014 |
| Marine Management Organisation (MMO) UK Sea Fisheries Monthly Reports and Annual Statistics Reports. | Commercial fisheries specific data (national and regional coverage).<br>Used to provide data related to fisheries landings and fishing effort within the area. | Coverage across UK waters, full coverage of the study area. | 2020-2022 |
| Defra spawning and nursery maps for mobile species considered to be of conservation importance (Ellis *et al.*, 2012). | Spawning and nursery ground maps for fish and shellfish species in the area.<br>Used to assess the presence of spawning and nursery ground located within the area. | Coverage across UK waters, full coverage of the study area. | 2010 |
| Fisheries Sensitivity Maps in British Waters (Coull *et al.*, 1998) | | | 1998 |
| The International Herring Larval Survey (IHLS) data (International Council for the Exploration of the Sea (ICES), 2007-2020). | Time-series acoustic data on spawning herring distribution used to characterise the spawning herring populations throughout European seas. | Coverage across the UK, full coverage of the study area. | 2007-2020 |

| Data Source | Data Summary | Spatial coverage | Temporal coverage |
|---|---|---|---|
| ICES North Sea International Bottom Trawl Survey (NSIBTS) data (ICES, 1965-2022) | Time-series groundfish survey data collected throughout European seas used to characterise the fish assemblage. | Coverage across the UK, within VE study area annual trawls undertaken south of the VE array areas. | 1965-2022 |
| Cefas Young Fish Survey data (Burt *et al.*, 2019) | Time-series beam trawl survey data in inshore areas around the British Isles. | Trawls undertaken within inshore locations of VE study area. | 1981 to 2010 |
| Cefas Blackwater spawning herring Surveys (Cefas, 1989-2009) | Trawls undertaken across the Thames estuary to assess the status of the Blackwater spawning herring stocks. | Coverage of the Thames Estuary. Partial coverage of the inshore waters of the southwestern extent of the study area. | 1989 to 2009 |
| Kent and Essex Inshore Fisheries and Conservation Authority (KEIFCA) Thames Estuary Cockle Survey Report (Haupt, 2022). | Used to assess the status of commercially important fish stocks within the area. | Coverage of the Thames Estuary. Partial coverage of the inshore waters of the southwestern extent of the study area. | 2022 |
| KEIFCA Oyster Survey Report (Dyer, 2019) | | Coverage of the Blackwater, Crouch, Roach and Colne Estuaries Marine Conservation Zone (MCZ). Coverage of discrete area in western extent of study area, to the south of the ECC. | 2019 |
| Eastern Inshore Fisheries and Conservation Authority (EIFCA) Whelk Technical Summary Report – Review of whelk permit Conditions (EIFCA, 2020). | | Coverage of the eastern IFCA. Partial coverage of inshore waters within northern extent of the study area. | 2020 |

| Data Source | Data Summary | Spatial coverage | Temporal coverage |
|---|---|---|---|
| The Outer Thames Estuary Regional Environmental Characterisation (The Marine Aggregate Levy Sustainability Fund (MALSF), 2009). | Used to characterise fisheries activity in the Outer Thames Estuary. | Coverage of inshore areas of the study area, partial nearshore coverage of the VE ECC. | 2007-2008 |
| Information on species of conservation interest (Joint Nature Conservation Committee (JNCC), 2007). | Used to characterise specific native species of conservation interest within the area. | Coverage across UK waters, full coverage of the study area. | 2007 |
| ICES Fish Map (ICES, 2006). | Used to characterise the species located within and around the study area. | Coverage across UK waters, full coverage of the study area. | 2006 |
| Thames bass trawl survey (Walmsley, 2006). | Regional survey data for sea bass. | Coverage of the Thames Estuary. Partial coverage of the inshore waters of the southwestern extent of the study area. | 2006 |
| Thames spawning herring Survey (Walmsley, 2007). | Regional survey data for spawning herring. | | 2007 |
| Regional Seabed Monitoring Programme (RSMP) (Cooper and Barry, 2017) (data obtained from the One Benthic baseline tool[2]) | The dataset comprises of 33,198 macrofaunal samples (83% with associated data on sediment particle size composition) covering large parts of the UK continental shelf. | Good coverage across the study area and wider region. | 2017 |
| **Additional Data Sources** | | | |
| VE site specific benthic survey data collected in 2021, used to determine spawning habitat suitability (Fugro, 2022a,b). | | | |
| VE site specific geophysical survey data collected in 2021, used to determine spawning habitat suitability (Fugro, 2022c,d). | | | |

[2] https://rconnect.cefas.co.uk/content/25/

| Data Source | Data Summary | Spatial coverage | Temporal coverage |
|---|---|---|---|
| Benthic habitats data from the Benthic Ecology and Subtidal Characterisation Reports (Volume 6, Part 5, Annex 5.1 and Volume 6, Part 5, Annex 5.2) | | | |
| Commercial Fisheries baseline characterisation (Volume 6, Part 5, Annex 8.1) | | | |
| PSA sediment characteristics North Falls Offshore Site pre-construction survey data, used to inform herring habitat suitability (Fugro, 2021) | | | |

## 6.5 ASSESSMENT CRITERIA AND ASSIGNMENT OF SIGNIFICANCE

6.5.1 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts (see Volume 6, Part 1, Chapter 3: EIA Methodology).

6.5.2 Information about VE and the activities for all stages of the project life cycle (construction, O&M and decommissioning) have been combined with information about the environmental baseline to identify the potential interactions between VE and the environment. These potential interactions are known as potential impacts, the potential impacts are then assessed to give a level of significance of effect upon the receiving environment/ receptors.

6.5.3 The outcome of the assessment is to determine the significance of these effects against predetermined criteria.

### MAGNITUDE OF IMPACT

6.5.4 The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency and reversibility of a potential impact. The definitions of the levels of magnitude used in the assessment as shown in Table 6.4.

**Table 6.4: Impact magnitude definitions.**

| Magnitude | Description/ reason |
|---|---|
| High | The proposed development would result in a complete permanent change to baseline conditions and status of conservation features/ ecological functionality; or the proposed development would result in a change from baseline conditions that would affect the conservation status of the site or feature. This magnitude rating is defined as changes occurring beyond the project's operational lifetime. |
| Medium | The proposed development would result in change to the baseline conditions over the lifetime of the project; or the feature's conservation status would not be affected, but the impact is likely to be significant in terms of ecological objectives or populations. If, in light of full information, it cannot be clearly demonstrated that the impact will not adversely affect the conservation objectives, then the impact should be assessed as high. |
| Low | Minor change from the baseline but the impact is of limited temporal or physical extent. |

| Magnitude | Description/ reason |
|---|---|
| Negligible | Discernible or barely discernible change from baseline conditions that results in a slight alteration to the key characteristics or features of a receptor. |

## SENSITIVITIES OF THE RECEPTORS

6.5.5 The sensitivities of fish and shellfish receptors are defined by both their potential vulnerability to an impact from the proposed development, their recoverability, and the value or importance of the receptor. The following parameters are also considered for considering the vulnerability to impacts from VE:

- Timing of the impact: whether impacts overlap with critical life stages or seasons (i.e., spawning, migration); and
- Probability of the receptor-impact interaction occurring.

6.5.6 The determination of a receptor's vulnerability to an impact is based on the ability of a receptor to accommodate a temporary or permanent change. The assessment of the receptor's vulnerability also considers the mobility of the receptor. Receptors that have the ability to flee from an impact are considered less sensitive than those that are stationary and unable to flee. When applying this consideration to a fish and shellfish assessment, static receptors typically include shellfish of limited mobility, fish that will potentially be engaging in spawning behaviours, substrate dependant receptors, and eggs and larvae. On this basis, 'static' receptors are considered to be of increased vulnerability to an impact. In determining the overall sensitivity of a receptor to an impact. The vulnerability of a receptor to the impact is typically given the greatest weighting.

6.5.7 The recoverability of the receptor is defined as the extent to which a receptor will recover following an impact. The rate of recovery is also taken into consideration in this criterion. Regarding fish and shellfish receptors, the recoverability of a receptor typically relates to the ability of a receptor to return/recolonise an area after an impact, or for normal behaviours to resume.

6.5.8 The value and importance of a receptor is a measure of the importance of a receptor in terms of its relative ecological, social or economic value or status. Regarding fish and shellfish receptors, the value and importance of the receptors is primarily informed by the conservation status of the receptor, the receptor's role in the ecosystem, and the receptor's geographic frame of reference. Note that for stocks of species which support significant fisheries, commercial value is also taken into consideration.

6.5.9 The value and importance of the receptor is defined by the following criteria:

- High value and importance: Nationally important (i.e., Annex II species listed as features of SACs);

- Medium value and importance: Regionally important or internationally rare (i.e., MCZ/rMCZ features (species classified as features of conservation importance, or species that are of commercial value to the fisheries which operate within the North Sea);
- Low value and importance: Locally important or nationally rare (i.e., species of commercial importance but do not form a key component of the fish assemblages within the VE fish and shellfish study area); and
- Negligible value and importance: Not assessed to be particularly important or rare.

6.5.10 Regarding the weighting of the sensitivity criteria (vulnerability, recoverability and value and importance), greater weighting is typically assigned to the vulnerability of a receptor. Expert judgement is used as appropriate, in line with the Chartered Institute of Ecology and Environmental Management (CIEEM) 2018 Guidance (CIEEM, 2018), when applying the sensitivity criteria to the sensitivity assessment of receptors. For example, if receptors are considered of high value/importance, or have rapid recovery rates, these criteria may be given greater weighting in the assessment.

6.5.11 The definitions of terms relating to the sensitivity of fish and shellfish ecology chapters are detailed in Table 6.5.

**Table 6.5: Sensitivity/importance of the receptor**

| Receptor sensitivity/ importance | Definition |
|---|---|
| High | Nationally and internationally important receptors with high vulnerability and no ability for recovery. |
| Medium | Regionally important receptors with high vulnerability and no ability for recovery.<br>Nationally important receptors with medium to high vulnerability and low to medium recoverability. |
| Low | Locally important receptors with medium to high vulnerability and low recoverability.<br>Regionally important receptors with low vulnerability and medium recoverability.<br>Nationally important receptors with low vulnerability and medium to high recoverability. |
| Negligible | Receptor is not vulnerable to impacts regardless of value/ importance.<br>Locally important receptors with low vulnerability and medium to high recoverability. |

## SIGNIFICANCE OF POTENTIAL EFFECTS

6.5.12 The matrix used for the assessment of the significance of potential effects is described in Table 6.6. The magnitude of the impact is correlated against the sensitivity of the receptor to provide a level of significance.

6.5.13 It should be noted that expert judgement is used as appropriate, in line with the CIEEM 2018 Guidance (CIEEM, 2018), when determining the significance of effect.

6.5.14 For the purpose of this assessment any effect that is moderate or major is considered to be significant in EIA terms. Any effect that is minor or below is not significant with respect to the EIA Regulations.

**Table 6.6: Matrix to determine effect significance.**

| | | | Sensitivity | | | |
|---|---|---|---|---|---|---|
| | | | High | Medium | Low | Negligible |
| Magnitude | Adverse | High | Major | Major | Moderate | Minor |
| | | Medium | Major | Moderate | Minor | Negligible |
| | | Low | Moderate | Minor | Minor | Negligible |
| | Neutral | Negligible | Minor | Minor | Negligible | Negligible |
| | Beneficial | Low | Moderate | Minor | Minor | Negligible |
| | | Medium | Major | Moderate | Minor | Negligible |
| | | High | Major | Major | Moderate | Minor |

Note: shaded cells are defined as significant with regards to the EIA Regulations 2017[3].

## 6.6 UNCERTAINTY AND TECHNICAL DIFFICULTIES ENCOUNTERED

6.6.1 Mobile species exhibit varying spatial and temporal patterns. All regional survey data used to characterise the baseline (as detailed in Table 6.3, noting that no site specific fish surveys have been undertaken for VE), provide a semi-seasonal description of the fish and shellfish assemblages within the fish and shellfish study area. It should be noted, however, that the data collected during fish surveys represent snapshots of the fish and shellfish assemblage within the study area at the time of sampling, and the fish and shellfish assemblages may vary considerably both seasonally and annually. However, should species be absent from the regional surveys, the outcome is not then to exclude consideration of these species from the baseline characterisation. Rather, the baseline description draws upon (or defaults

[3] The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

to) wider scientific literature, as this provides a more thorough, robust, and longer time series evidence base, which therefore ensures a more comprehensive and precautionary baseline, identifying all species that are likely to be present within the study area.

6.6.2 It should also be noted that the methods of surveying fish and shellfish (regarding the regional fish surveys as detailed in Table 6.3) vary in their efficiency at capturing different species. For example, otter and beam trawl surveys are ineffective at capturing information on pelagic fish species (such as spawning herring (*Clupea harengus*) and sprat (*Sprattus sprattus*)). This limits the data utility in capturing relative abundances of species within the area. To minimise this limitation caused by trawl methodology of the surveys, sensitive receptors have been chosen based on their presence or absence in surveys, rather than whether that species contributes more significantly to the fish assemblage in the survey data.

6.6.3 The description of spawning and nursery grounds provided in this report are primarily based on the information presented in Coull *et al*., (1998) and Ellis *et al*., (2012), data sources widely accepted across the offshore wind industry. The limitations of these sources of information should, however, be recognised. These publications provide an indication of the general location of spawning and nursery grounds, and the spawning periods of commercial fish species. It should, however, be acknowledged that spawning times presented in the publications represent the maximum duration of spawning on a species/stock basis. In some cases, the duration of spawning may be much more concentrated, on a site-specific basis, than reported in Coull *et al*., (1998) and Ellis *et al*., (2012). Therefore, where available, additional research publications have also been reviewed to provide site-specific information.

6.6.4 Additionally, Coull et al., (1998) and Ellis *et al*., (2012) do not define precise boundaries of spawning and nursery grounds. However, when considering demersal spawners which display substrate dependency (e.g., spawning herring and sandeel), site-specific PSA and geophysical data (collected along the VE offshore ECC and in the array areas) are used to ground truth the Coull *et al*., (1998) and Ellis *et al*., (2012) datasets.

6.6.5 The EUSeaMap (2021) broadscale marine habitat data is used as one of the data sets to identify preferred sandeel and herring spawning habitats. It should be acknowledged however that this dataset is limited by the broadscale nature of the dataset, since it does not account for small scale, localised differences in seabed sediments, unlike the data obtained from site-specific grab sampling. In this case it is important to review all of the datasets presented, to develop a clear overview of preferred sandeel and spawning herring habitat.

6.6.6 Site-specific PSA data and geophysical survey data have therefore been collected along the VE offshore ECC and in the array areas, to confirm and validate broadscale marine habitat data (Coull *et al*., 1998; Ellis *et al*., 2012; EUSeaMap, 2021). These data have been classified in accordance with the Latto *et al*., (2013) and Reach *et al*., (2013) classifications, and a heatmapping exercise undertaken in accordance with methodologies outlined by MarineSpace et al. (2013) to identify areas of preferred spawning habitat for sandeel and spawning herring respectively. The use of PSA data and broadscale habitat mapping provides a proxy for the presence of sandeel and herring spawning habitat in these locations (based on suitability of habitats, i.e., the potential for spawning rather than actual contemporary spawning activity). In addition, whilst grab samples provide detailed information on the sediment types, they cannot cover wide swaths of the seabed and consequently only represent point samples. The PSA data is therefore interpreted in combination with additional PSA data across the site, sourced from the British Geological Society (BGS) (2015), to provide comprehensive cover of the fish and shellfish study area. It is important to note, that although the data used in the characterisation of the fish and shellfish baseline conditions (as detailed in Table 6.3) span a long time period, with some sources published over a decade ago, the information presented represents a long-term dataset. Accordingly, this allows for a detailed overview of the characteristic fish and shellfish species in the study area. The diversity and abundance of many species, particularly demersal fish species, is linked to habitat types, which have remained relatively constant in the study area, indicating no major shift in the fish and shellfish communities over the time period of the data used in this report.

6.6.7 There are limitations to using spawning substrates to inform the locations of spawning herring and MarineSpace et al. (2013) acknowledge that habitat sediment classification is not the only parameter that indicates potential spawning habitat.. There are other environmental (physical, chemical and biotic) parameters such as: oxygenation, siltation, overlap with range of spawning populations, micro-scale seabed morphological features e.g. ripples and ridges; which all contribute to the suitability of seabed habitat to be used as spawning beds by herring. As such the habitat sediment classes alone will always over-represent the range of habitat with the potential to support spawning events (MarineSpace et al. 2013).

6.6.8 Due consideration should be given, regarding sources of uncertainty in the underwater noise assessment process, due to a lack of research into the effects of the particle motion element of underwater noise (an impact considered more important than sound pressure for many species), particularly invertebrates. As a consequence of the lack of research into this topic there are currently no criteria for assessing the impact of particle motion, and therefore it is not possible to undertake a threshold-based assessment of the potential for impact to shellfish in the same way as can be done for fish. As such, qualitative assessments have been undertaken based on peer-reviewed literature.

6.6.9 Despite the data limitations and uncertainties detailed within this section of the report, the data as detailed in Table 6.3 provides a robust and sufficient evidence base to inform the fish and shellfish baseline characterisation and underpin the assessment.

## 6.7 EXISTING ENVIRONMENT

### OVERVIEW

6.7.1 A detailed characterisation of the fish and shellfish baseline environment is provided in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, with a summary provided here. This ES chapter should therefore be read alongside the detailed fish and shellfish characterisation annex.

### FISH AND SHELLFISH ASSEMBLAGE

6.7.2 A wide range of fish and shellfish species are expected to inhabit the VE study area. Beam trawls conducted as part of the North Sea International Bottom Trawl Surveys (NSIBTS) were dominated in Norway pout (*Trisopterus esmarkii),* haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) from 2018 to 2022. Trawls undertaken in 2020 were also dominated by American plaice (*Hippoglossoides platessoides*) and Nephrops (*Nephrops norvegicus*), and high abundances of silvery pout (*Gadiculus argenteus*) were recorded in 2021 (ICES, 1965-2022).

6.7.3 Cefas young fish surveys undertaken along the south and east coasts of the British Isles, recorded a species composition dominated by goby species (*Pomatoschistus* spp.), dab (*Limanda limanda*), common sole (*Solea solea*), plaice (*Pleuronectes platessa*), hooknose (*Agonus cataphractus*), and common dragonet (*Callionymus lyra*) from 2000 to 2010 (Burt *et al.*, 2019).

6.7.4 The characterising species recorded within site specific surveys for a number of local OWF projects (Greater Gabbard OWF, Galloper OWF, London Array OWF and Gunfleet Sands OWF) showed good agreement with the main species recorded within the more recent regional surveys, suggesting that monitoring data from local OWF development remains relevant for characterisation of the VE site.

### SPAWNING AND NURSERY GROUNDS

6.7.5 This section describes fish species which have spawning and nursery areas that overlap, or are in close proximity to, the VE array areas or ECC.

6.7.6 Spawning and nursery areas are categorised by Ellis *et al*., (2012) as either 'high' or 'low intensity' dependent on the level of spawning activity or abundance of juveniles recorded in these habitats. Coull *et al*., (1998) does not always provide this level of detail. The spatial extent of the spawning grounds and the duration of spawning periods indicated in these studies are therefore considered likely to represent the maximum theoretical extent of the areas and periods within which spawning will occur.Several species of fish and shellfish are known to either spawn or have nursery areas in relatively close proximity to, or potentially overlapping with the VE study area (Coull *et al*., 1998; Ellis *et al*., 2010). These spawning and nursery sites identified within and in proximity to VE are presented in Figure 6.4. Table 6.8 provides a summary of spawning timings for the identified spawning grounds within and in proximity to VE.

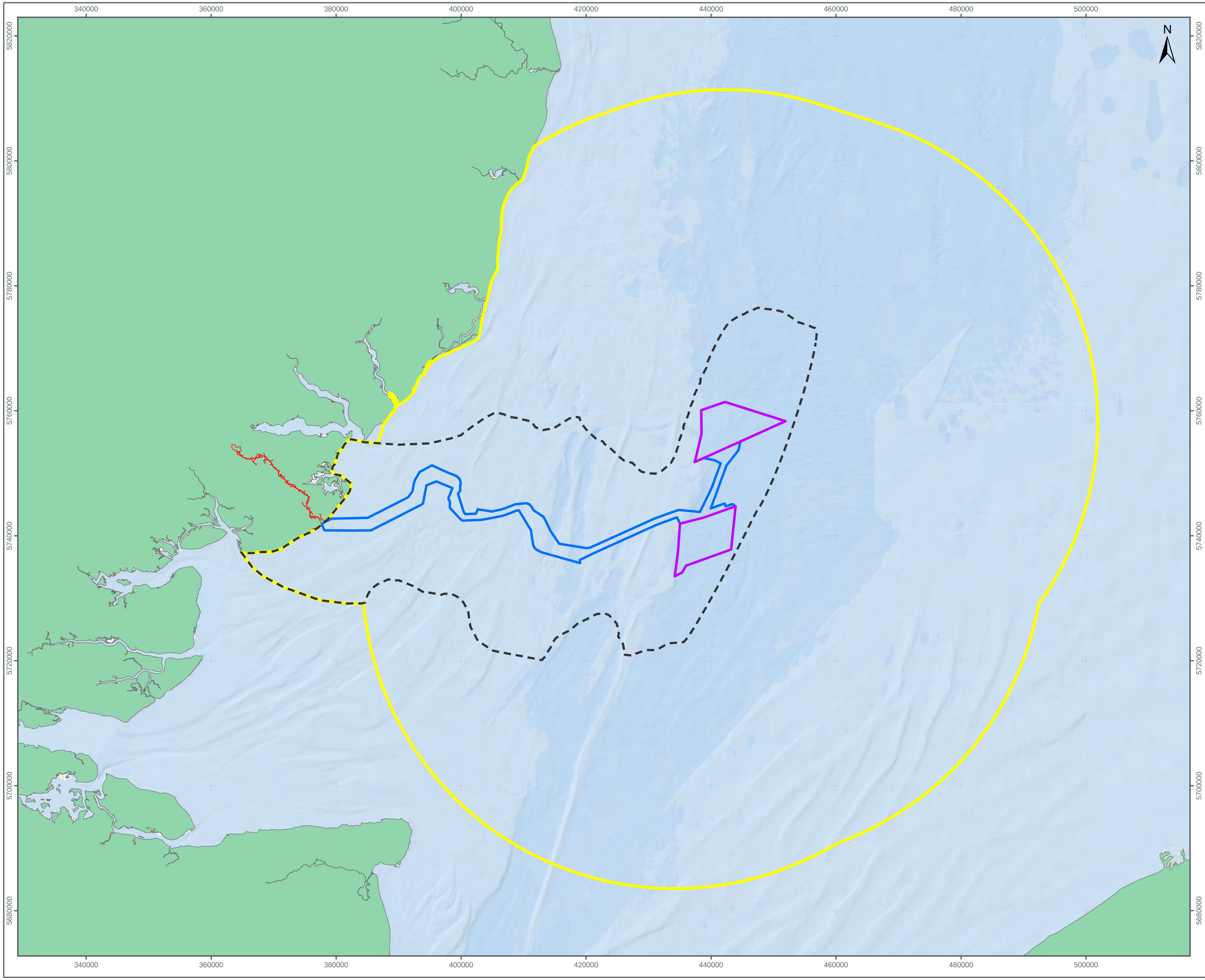
6.7.7 Due to the demersal spawning nature of herring and sandeel, and therefore their increased sensitivity to potential impacts from the development, herring and sandeel have been addressed separately below. The spawning and nursery grounds (Coull *et al*., 1998 and Ellis *et al*., 2010), discussed and illustrated below are considered robust sources of information, as the physical drivers such as sediment type remain the same (EUSeaMap, 2021) and are supplemented by project specific PSA and geophysical survey data.

6.7.8 'High intensity' spawning grounds overlap the VE study area for plaice and sole (Figure 6.3 and Figure 6.4) (Ellis *et al*., 2012), both plaice and sole spawning grounds are significant in size and therefore the interaction between the sites and the VE study area is small. Species with low intensity spawning grounds that cross the study area (as well as widely around the UK) include cod, horse mackerel (*Trachurus trachurus*) and sandeel (Ellis *et al*., 2012).

6.7.9 There are also spawning grounds present across the study area for mackerel (*Scomber scombrus*), sprat, whiting and lemon sole (*Microstomus kitt*) (Coull *et al*., 1998) (see Figure 6.3 and Figure 6.4), these spawning grounds are significant in size and therefore the interaction between the sites and the study area is small.

6.7.10 The North Sea provides important nursery ground habitat for a variety of fish species. 'Low intensity' nursery grounds that intersect the study area are present for cod, mackerel, plaice, sandeel, sole, thornback ray, tope and whiting (Ellis *et al*., 2012). A 'high intensity' herring nursery ground also overlaps the nearshore section of the offshore ECC (Ellis *et al*., 2012). Nursery grounds for lemon sole and sprat also intersect the study area (Coull *et al*., 1998). Nursery grounds for these species are significant in size, with coverage across much of the southern North Sea and the eastern Channel.

6.7.11 Key nursery areas for European seabass are present across the wider Thames estuary (Hyder *et al*., 2018). The nearest seabass nursery area to VE is located within the Blackwater estuary, approximately 23 km from the offshore ECC, outside of study area (Figure 6.10).




LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Fish and Shellfish Study Area
- Sedimentary ZoI

0 5 10 20
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

*FIVE ESTUARIES OFFSHORE WINDFARM*

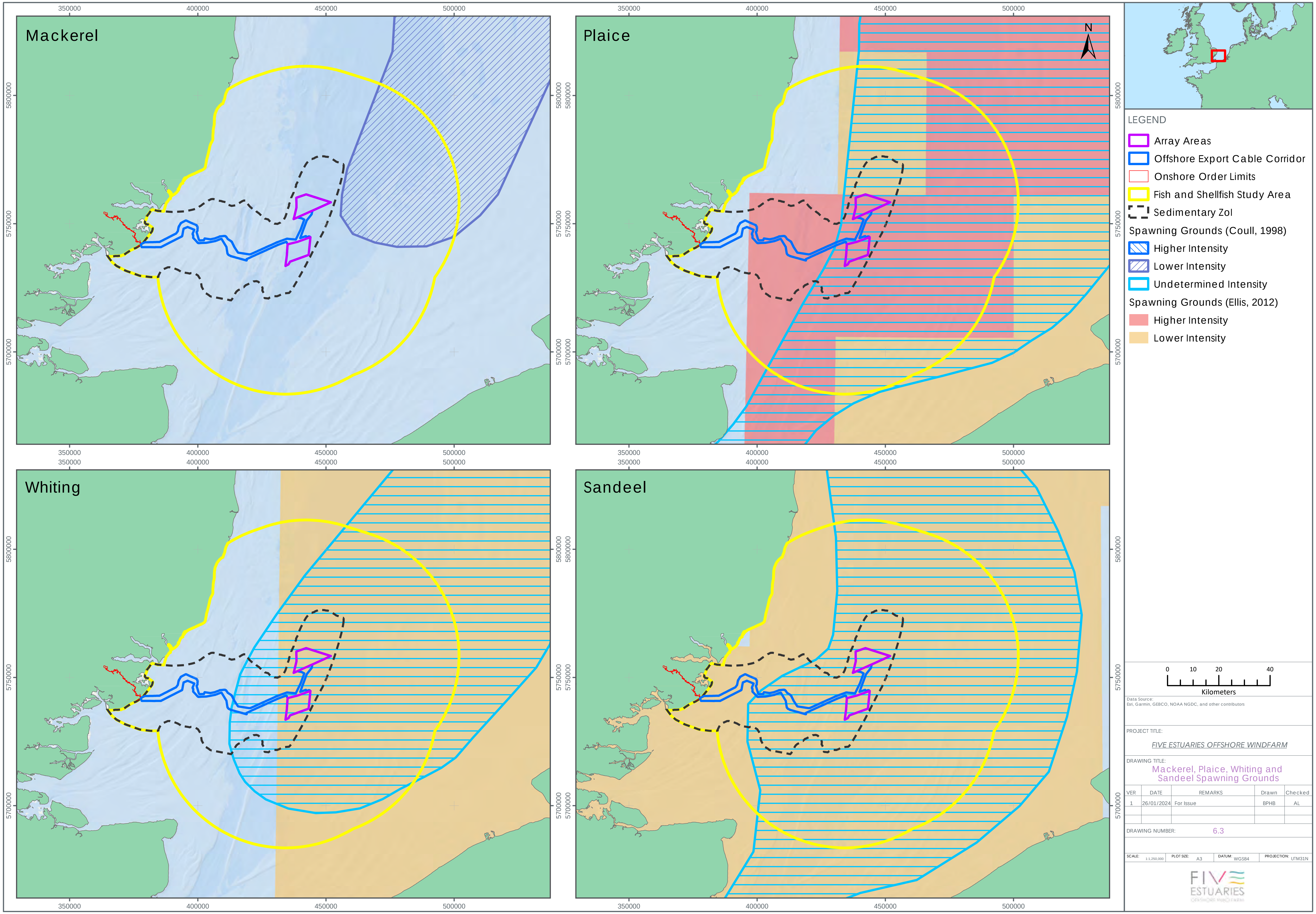
DRAWING TITLE:

Fish and Shellfish Study Area

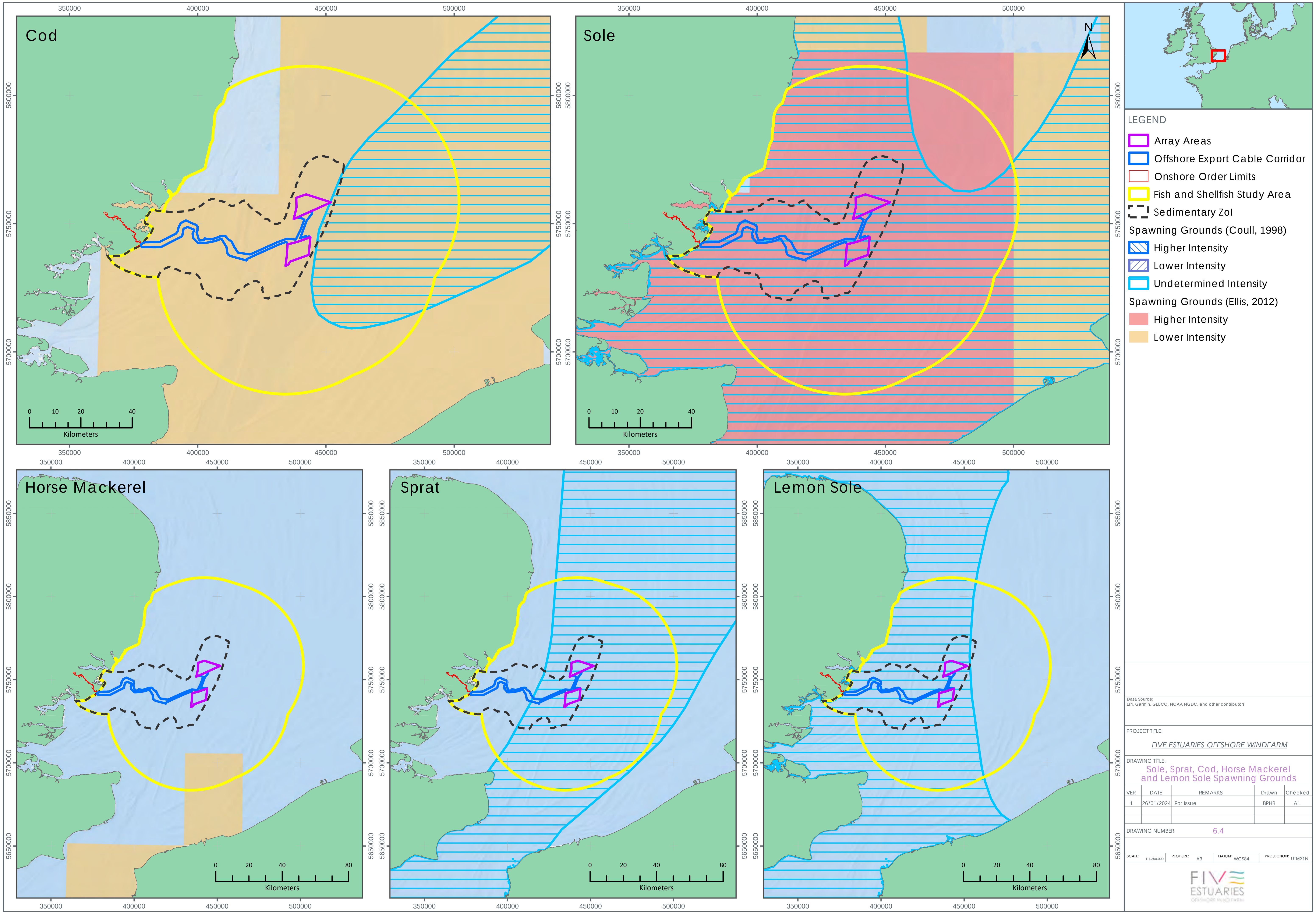
| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.2

| SCALE: 1:550,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|



Mackerel
Plaice
Whiting
Sandeel
N
350000
400000
450000
500000
5800000
5750000
5700000
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Fish and Shellfish Study Area
Sedimentary ZoI
Spawning Grounds (Coull, 1998)
Higher Intensity
Lower Intensity
Undetermined Intensity
Spawning Grounds (Ellis, 2012)
Higher Intensity
Lower Intensity
0 10 20 40
Kilometers
Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Mackerel, Plaice, Whiting and Sandeel Spawning Grounds
VER DATE REMARKS Drawn Checked
1 26/01/2024 For Issue BPHB AL
DRAWING NUMBER: 6.3
SCALE: 1:1,250,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES



Cod
Sole
Horse Mackerel
Sprat
Lemon Sole
N
Kilometers
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Fish and Shellfish Study Area
Sedimentary ZoI
Spawning Grounds (Coull, 1998)
Higher Intensity
Lower Intensity
Undetermined Intensity
Spawning Grounds (Ellis, 2012)
Higher Intensity
Lower Intensity
Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Sole, Sprat, Cod, Horse Mackerel and Lemon Sole Spawning Grounds
VER | DATE | REMARKS | Drawn | Checked
1 | 26/01/2024 | For Issue | BPHB | AL
DRAWING NUMBER: 6.4
SCALE: 1:1,250,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES

**Table 6.7: Summary of fish spawning and nursery habitats within the VE fish and shellfish study area from data presented in Coull *et al*., 1998 and Ellis *et al*., 2010; 2012.**

| **Spawning Habitat** | | | | **Nursery Habitat** | | |
|---|---|---|---|---|---|---|
| **Receptor** | **Description** | **Distance to Arrays (km)** | **Distance to Offshore ECC (km)** | **Description** | **Distance to Arrays (km)** | **Distance to Offshore ECC (km)** |
| Plaice | High intensity spawning ground coinciding with VE study area. | 0 | 0 | Low intensity nursery ground coinciding with VE study area. | 35.2 | 0 |
| Common sole | High intensity spawning ground coinciding with VE study area. | 0 | 0 | Low intensity nursery ground coinciding with VE study area. | 35.6 | 3 |

| Spawning Habitat | | | | Nursery Habitat | | |
| --- | --- | --- | --- | --- | --- | --- |
| Cod | Low intensity spawning ground coinciding with VE study area. | 0 | 0 | Low intensity nursery ground coinciding with VE study area. | 0 | 0 |
| Horse mackerel (*Trachurus trachurus*) | Low intensity spawning ground coinciding with VE study area. | 27.5 | 31.9 | No known nursery grounds in VE study area. | N/A | N/A |
| Sandeel | Low intensity spawning ground coinciding with VE study area. | 0 | 0 | Low intensity nursery ground coinciding with VE study area. | 0 | 0 |

| Spawning Habitat | | | | Nursery Habitat | | |
|---|---|---|---|---|---|---|
| Herring (Downs stock) | An area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998) overlaps with a portion to the east of the southern VE array area. | 2.9 | 0 | High intensity herring nursery ground overlaps the nearshore section of the offshore ECC. | 23.5 | 0 |
| Herring (Blackwater/Thames stock) | Blackwater/Thames spawning ground in the Blackwater estuary, south off the nearshore section of the offshore ECC. | 67.2 | 9.6 | | | |
| Mackerel (*Scomber scombrus*) | Low intensity spawning ground coinciding with VE study area. | 4.3 | 11.1 | Low intensity nursery ground coinciding with VE study area. | 0 | 0 |

| Spawning Habitat | | | | Nursery Habitat | | |
|---|---|---|---|---|---|---|
| Sprat | Spawning ground coinciding with VE. | 0 | 0 | Nursery ground coinciding with VE study area. | 0 | 0 |
| Whiting | Spawning ground coinciding with VE. | 0 | 0 | Low intensity nursery ground coinciding with VE study area. | 25.3 | 0 |
| Lemon sole | Spawning ground coinciding with VE. | 0 | 0 | Nursery ground coinciding with VE study area. | 0 | 0 |
| Thornback ray | No known spawning grounds in VE study area. | N/A | N/A | Low intensity nursery ground coinciding with VE study area. | 3.1 | 0 |

| Spawning Habitat | | | | Nursery Habitat | | |
|---|---|---|---|---|---|---|
| Tope | No known spawning grounds in VE study area. | N/A | N/A | Low intensity nursery habitat coinciding with VE study area. | 0 | 0 |
| European seabass | No known spawning grounds in VE study area. | N/A | N/A | Key nursery areas present across wider Thames estuary, the nearest is within the Blackwater estuary. | 79.3 | 22.47 |

**Table 6.8: Summary of spawning timings in the Southern North Sea for fish species known to have spawning habitats in the VE study area (Light blue indicates spawning period, dark blue indicates peak spawning period).**

| Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plaice | Peak | Peak | Spawning | | | | | | | | | |
| Sole | | | Spawning | Peak | Spawning | | | | | | | |
| Cod | Spawning | Peak | Peak | Spawning | | | | | | | | |
| Horse mackerel | | | Spawning | Spawning | Peak | Peak | Spawning | Spawning | | | | |
| Sandeel | Spawning | Spawning | | | | | | | | | | |
| Herring (Downs stock) | Peak | | | | | | | | | | Peak | Peak |
| Herring (Thames/Blackwater stock) | | Peak | Peak | Spawning | Spawning | | | | | | | |
| Mackerel | | | | | Peak | Peak | Peak | Spawning | | | | |
| Sprat | | | | | Peak | Peak | Spawning | Spawning | | | | |
| Whiting | | Spawning | Spawning | Spawning | Spawning | Spawning | | | | | | |
| Lemon sole | | | | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | | | |
| Thornback ray | | Spawning | Spawning | Peak | Peak | Peak | Peak | Peak | Spawning | | | |
| Tope | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning | Spawning |
| European seabass | | | Spawning | Spawning | Spawning | Spawning | | | | | | |

### HERRING

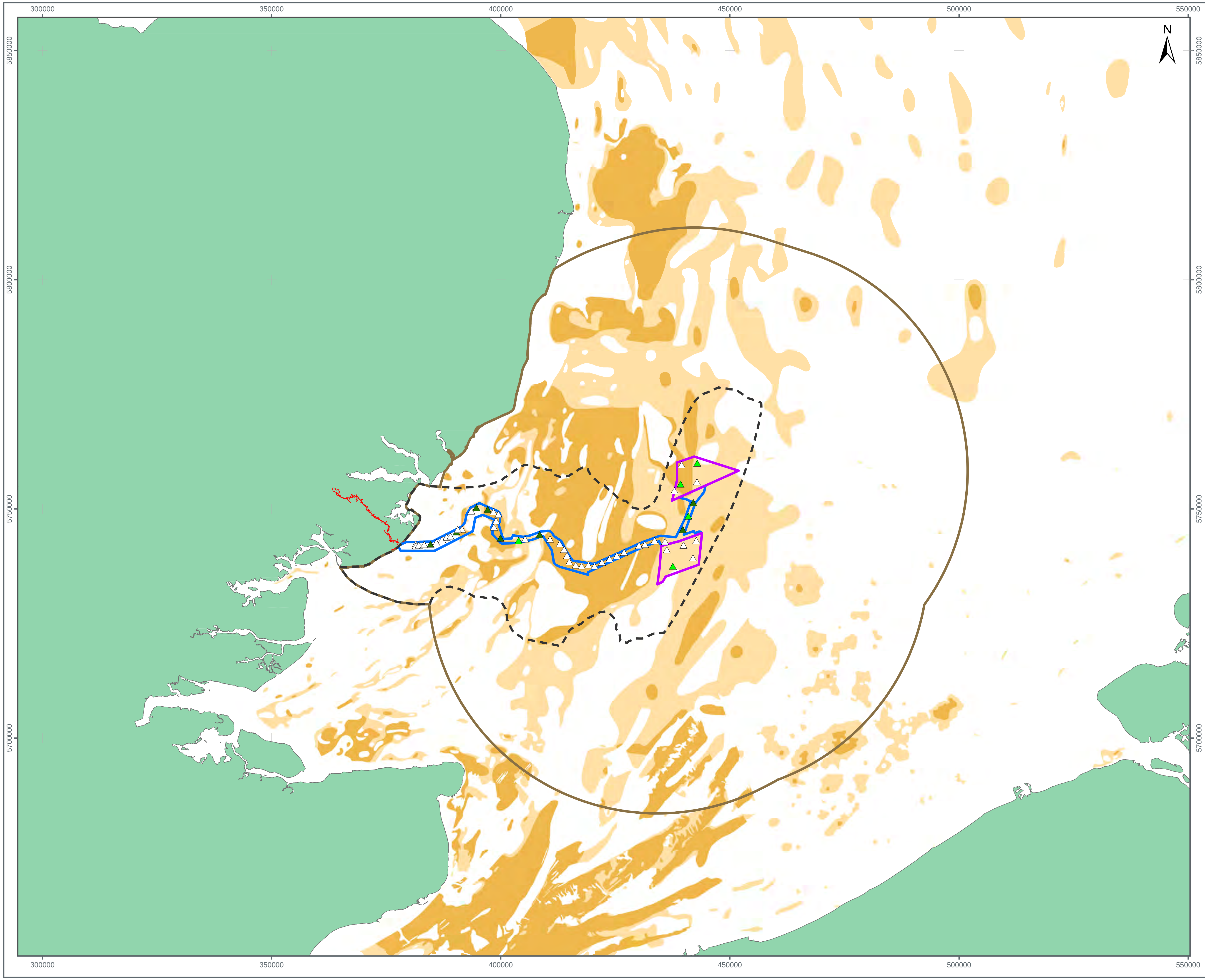
6.7.12 A herring spawning ground intersects with the western side of the study area (Coull *et al*., 1998) (see Figure 6.6. Furthermore, there is a herring spawning ground located in the Blackwater estuary, approximately 10 km south of the nearshore section of the offshore ECC.

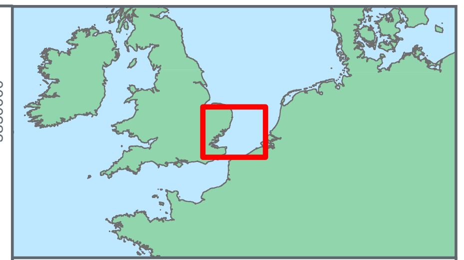
6.7.13 The preferred sediment habitat for herring spawning is gravel, with some tolerance of more sandy sediments, although these are primarily on the edge of any spawning grounds (Stratoudakis *et al.*, 1998). Herring spawning beds are typically small, localised features. Actual spawning habitat, or habitat that could be used for spawning activity, likely comprises relatively small seabed features, with discrete spatial extents, although these may be spread across wide areas of suitable seabed spawning habitat at a regional scale (e.g., spawning grounds). Eggs are laid on the seabed, usually in water 10-80 m deep, in areas of gravel, or similar coarse habitats (e.g., coarse sand, shell and maerl), with well oxygenated waters (Ellis *et al*., 2012; Bowers, 1980; Groot, 1980; Rakine, 1986, Aneer, 1989; Stratoudakis *et al*., 1998).

6.7.14 As informed by site specific survey data (PSA, and geophysical data), and broadscale marine habitat mapping (EMODnet 1:250,000 seabed sediment maps) the presence of potentially suitable spawning substrates have been identified within the array areas and ECC, and as indicated by herring larval densities (IHLS, 2007-2020) (as a proxy for active spawning) low intensity spawning occurs within the southern array area, which overlaps with a historic herring spawning ground (as defined by Coull et al, 1998). However, on a broader scale, significantly larger areas of 'Preferred' spawning substrates (on account of their gravel content) are located to the south of the array areas, within the Dover Strait and eastern English Channel, where higher intensity spawning activity is apparent (as indicated by higher herring larval densities) (Figure 6.6).

6.7.15 A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium to high confidence that the seabed may be suitable for spawning (Figure 6.7). This is due to the overlap of this portion of the southern array with the historic herring spawning ground (as defined by Coull *et al*., 1998), the presence of 'Marginal' spawning substrates, and densities of >600 herring larvae per m$^2$. However, on a broader scale, 'Preferred' spawning substrates, and significantly higher densities of herring larvae are located to the south of the array areas. The Dover Strait is predominantly classified as 'Preferred' spawning substrates for herring, with larval densities ranging from 14,000 to 35,000 larvae per m$^2$, significantly higher than the larval densities within the VE array areas (0.1 – 7,000 m$^2$) and corresponding with the locations of spawning substrates. Further south, within the eastern English Channel, larval densities are at their highest, peaking at 98,500 larvae per m$^2$, and aligning with the broadscale distribution of 'Preferred' spawning substrates (Figure 6.12).

6.7.16 Therefore, based on the available evidence outlined above, the area is considered to be unlikely to be a hotspot for herring spawning and if spawning does occur it is likely to be at low levels.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Fish and Shellfish Study Area
- Sedimentary ZoI

Herring Habitat Suitability (Reach *et al.*, 2013)

- Prime, Preferred
- Suitable, Marginal
- Unsuitable

Herring Suitability (EMODnet Data)

- Marginal
- Preferred

0 5 10 20
Kilometers

Data Source:

PROJECT TITLE:

*FIVE ESTUARIES OFFSHORE WINDFARM*

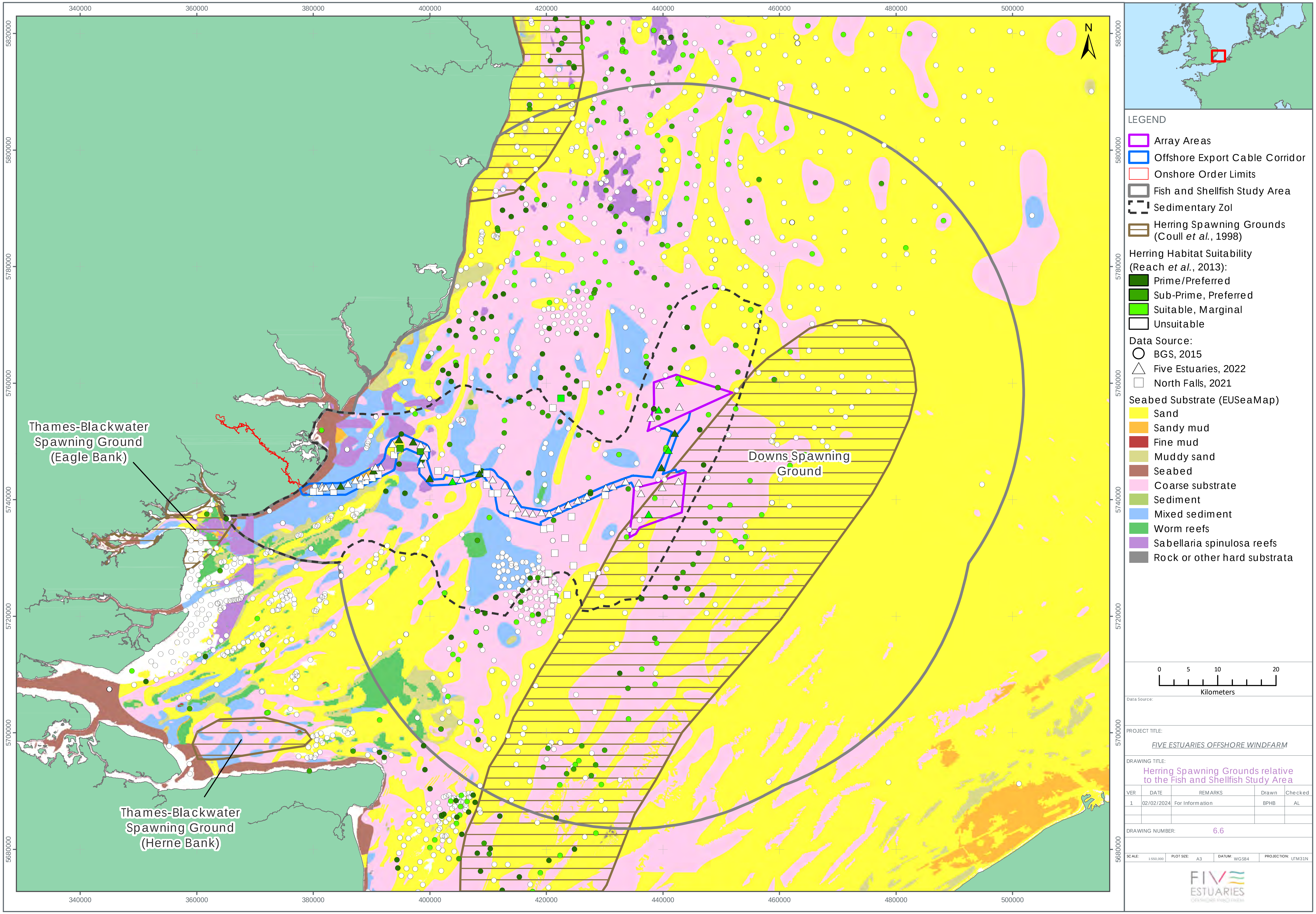
DRAWING TITLE:

Herring Spawning and Nursery Grounds

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.5

| SCALE: 1:750,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|




LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Herring Spawning Grounds (Coull *et al.*, 1998)

Herring Habitat Suitability (Reach *et al.*, 2013):

- Prime/Preferred
- Sub-Prime, Preferred
- Suitable, Marginal
- Unsuitable

Data Source:

- BGS, 2015
- Five Estuaries, 2022
- North Falls, 2021

Seabed Substrate (EUSeaMap)

- Sand
- Sandy mud
- Fine mud
- Muddy sand
- Seabed
- Coarse substrate
- Sediment
- Mixed sediment
- Worm reefs
- Sabellaria spinulosa reefs
- Rock or other hard substrata

0 5 10 20
Kilometers

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

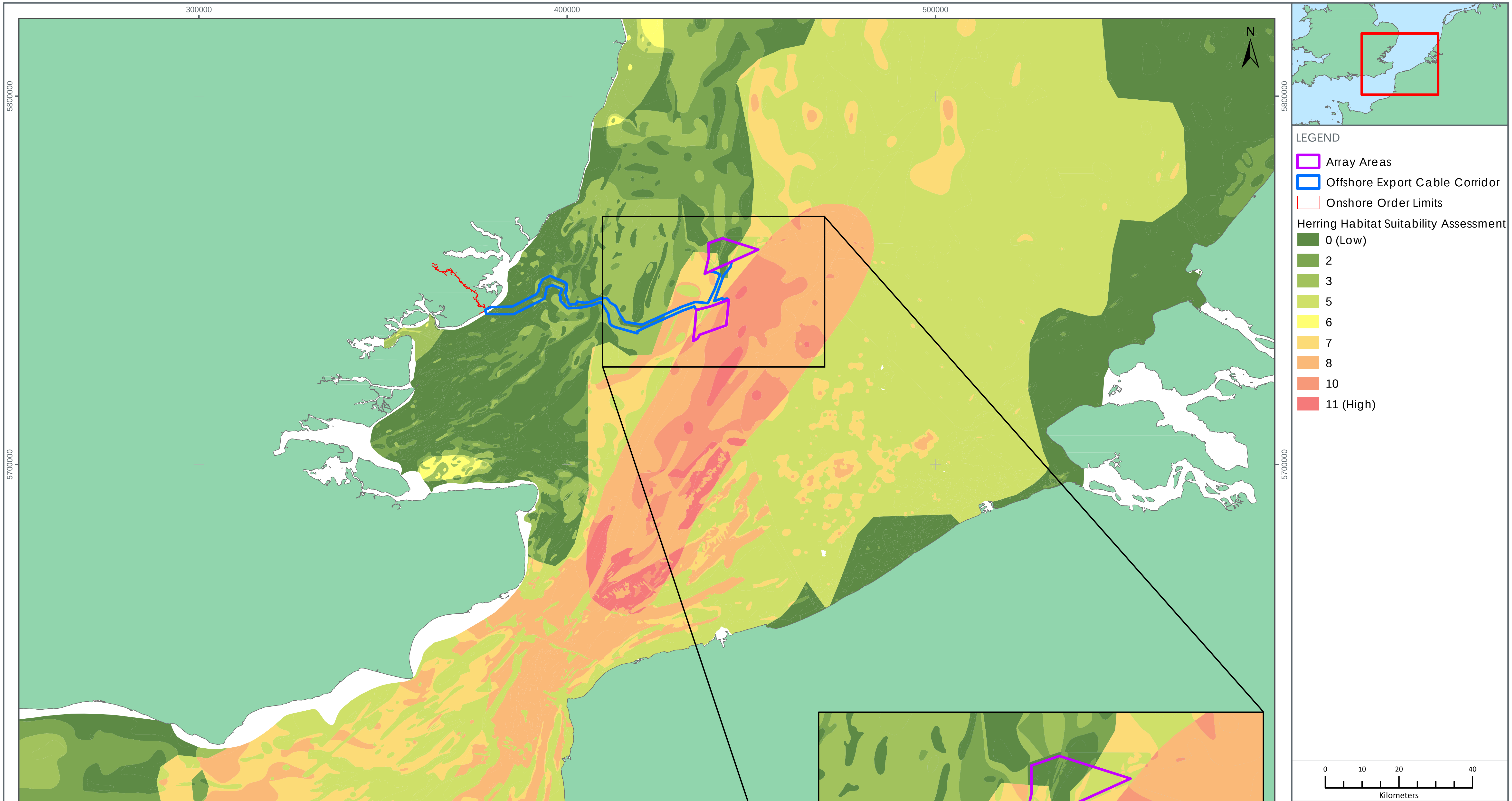
DRAWING TITLE:

Herring Spawning Grounds relative to the Fish and Shellfish Study Area

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 02/02/2024 | For Information | BPHB | AL |

DRAWING NUMBER: 6.6

| SCALE: 1:550,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|




Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Herring Spawning Potential Heat Map

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Issue | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.7

SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

## SANDEEL

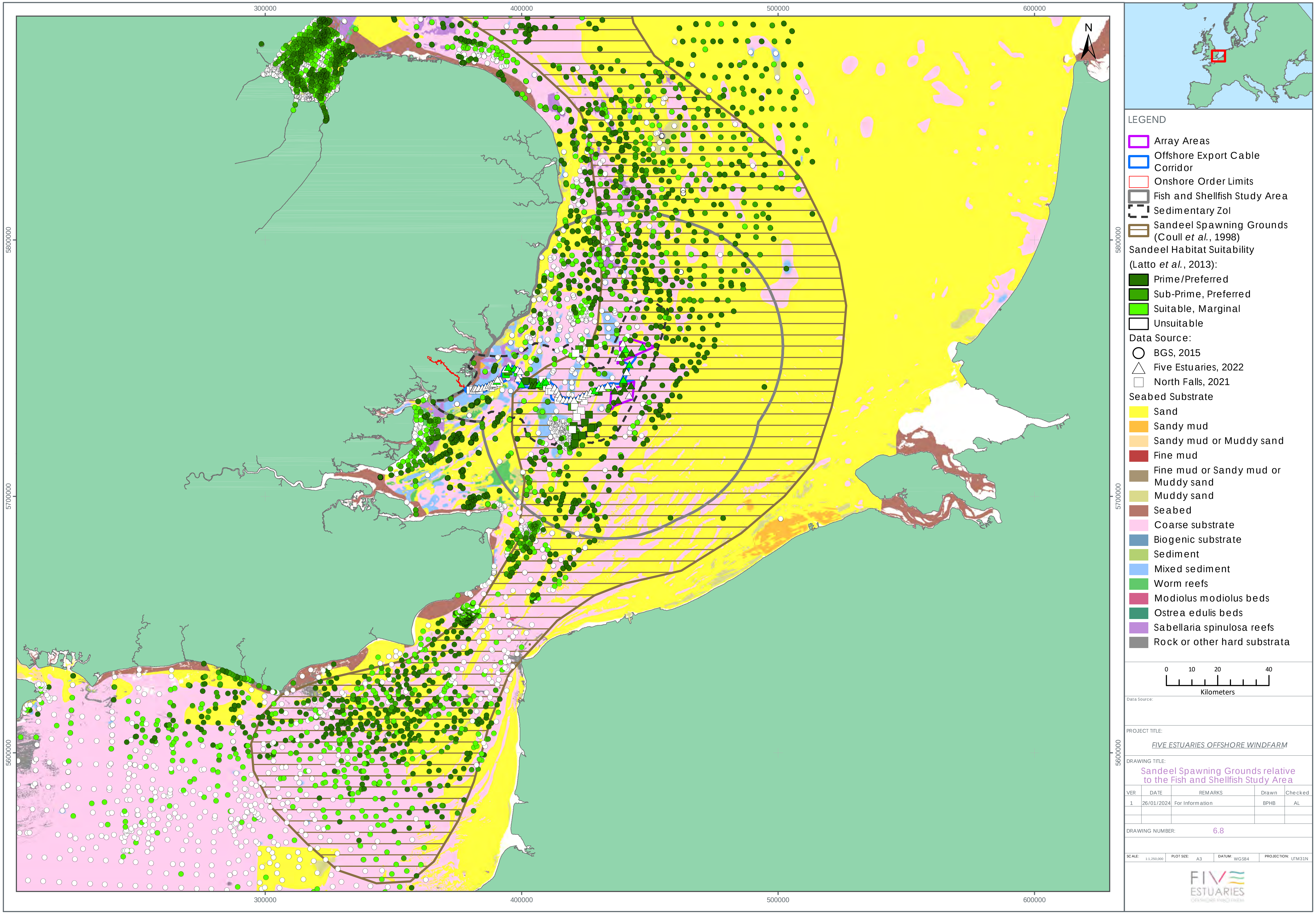
6.7.17 Sandeels are a group of shoaling fish which lie buried in seabed sediments at night and feed on planktonic prey such as copepods and crustacean larvae in mid-water during daylight hours. Sandeels are an important trophic level in the North Sea food chain, providing a key link between zooplankton and higher tropic predators such as piscivorous fish, most seabirds and mammals. As many marine predators rely on sandeels, coupled with their vulnerability to changes in habitat, sandeels are of increasing conservation interest and listed as a species of principal importance in the UK and designated as a nationally important marine feature.

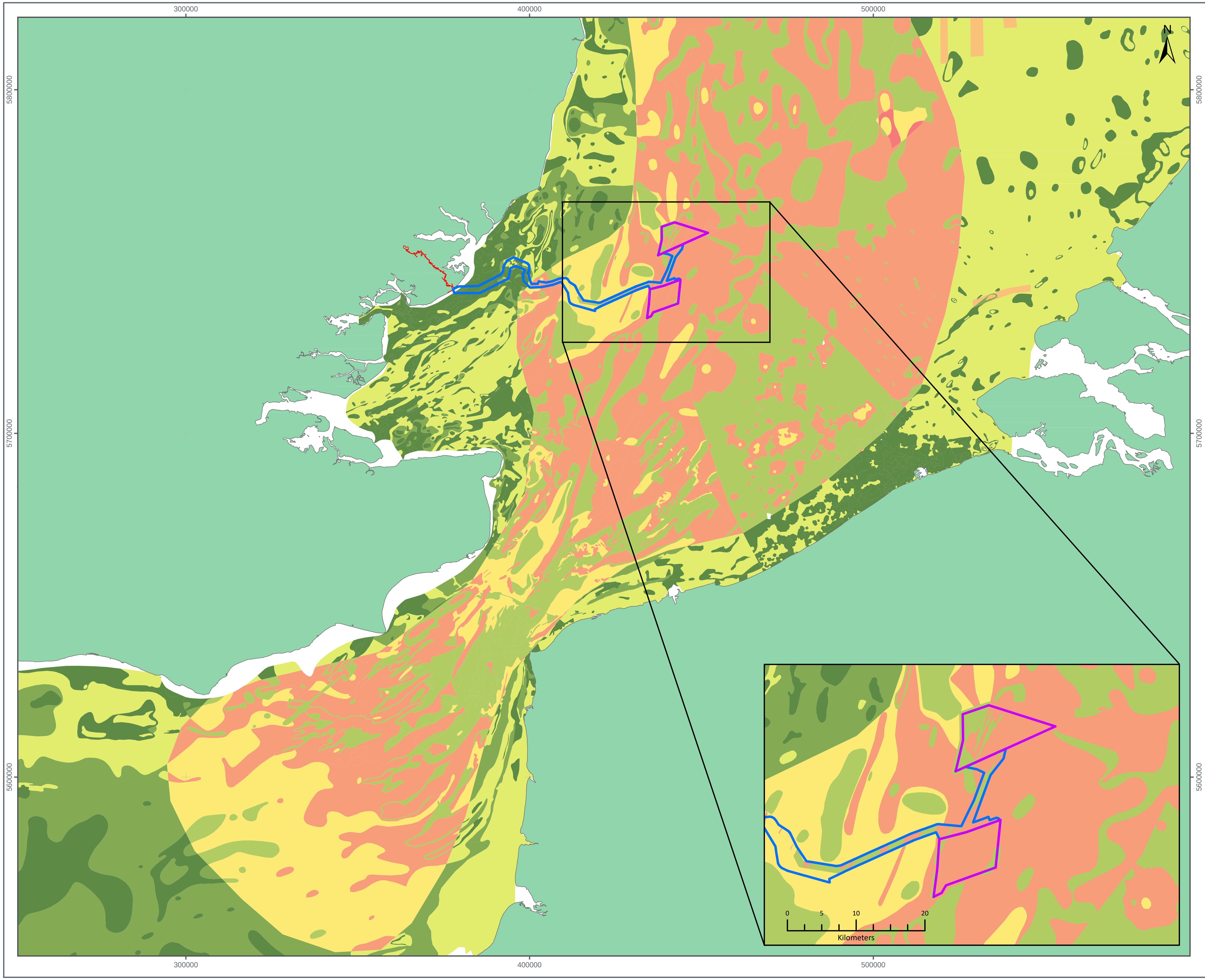
6.7.18 Sandeel spawn in coarse sediments although, their preferred spawning habitats are sandier than those of herring. Sandeel prefer habitats composed of sand to gravelly sand but will tolerate sandy gravels as a marginal spawning habitat. Sandeel spawning grounds occur across the southern North Sea, and have spawning grounds which overlap the fish and shellfish study area.

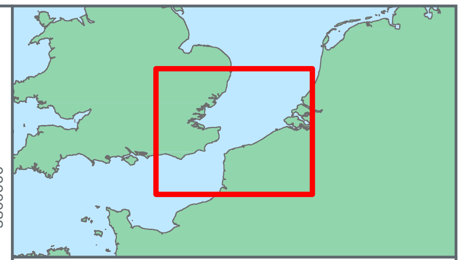
6.7.19 As informed by site specific survey data (PSA, and geophysical data), and broadscale marine habitat mapping (EMODnet 1:250,000 seabed sediment maps), the presence of potentially suitable spawning substrates have been identified within the array areas and mid-section of the ECC, which are located within a historic sandeel spawning ground (as defined by Coull *et al.*, 1998). However, on a broader scale, significantly larger areas of 'Preferred' spawning substrates (on account of their sand content) are located across the southern North Sea, Dover Strait and eastern English Channel, within the defined sandeel spawning ground (Figure 6.8). A heat mapping exercise (detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) indicates that the VE array areas and mid-section of the Offshore ECC lie within an area of high data confidence that the seabed may be suitable for spawning, due to the presence of 'Preferred' spawning substrates for sandeel, and the overlap of a historic spawning ground (as defined by Coull *et al*,.1998) (Figure 6.9).

6.7.20 The nearshore portion of the Offshore ECC has low data confidence that the seabed may be suitable for spawning (Figure 6.9), due to the absence of the historic sandeel spawning ground (as defined by Coull *et al.*, 1998) and absence of suitable spawning substrates within the ECC. The offshore portion of the ECC is of medium confidence due to the presence of 'Marginal' spawning substrates, and the overlap of offshore portion of the ECC with a historic sandeel spawning ground.

6.7.21 Whilst the VE array areas and mid-section of the Offshore ECC lie within an area of high data confidence (Figure 6.9), indicative of a higher confidence that the seabed may be suitable for sandeel spawning, on a broader scale, 'Preferred' spawning substrates for sandeel are also located across the majority of the southern North Sea, Dover Strait, and eastern English Channel. Furthermore, the historic sandeel spawning ground as defined by Coull *et al.*, (1998), also stretches across the southern North Sea. Therefore, based on the available evidence outlined above, the area is considered to be unlikely to be a hotspot for sandeel spawning.


300000
400000
500000
600000
5800000
5700000
5600000
N
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Fish and Shellfish Study Area
Sedimentary ZoI
Sandeel Spawning Grounds (Coull et al., 1998)
Sandeel Habitat Suitability (Latto et al., 2013):
Prime/Preferred
Sub-Prime, Preferred
Suitable, Marginal
Unsuitable
Data Source:
BGS, 2015
Five Estuaries, 2022
North Falls, 2021
Seabed Substrate
Sand
Sandy mud
Sandy mud or Muddy sand
Fine mud
Fine mud or Sandy mud or Muddy sand
Muddy sand
Seabed
Coarse substrate
Biogenic substrate
Sediment
Mixed sediment
Worm reefs
Modiolus modiolus beds
Ostrea edulis beds
Sabellaria spinulosa reefs
Rock or other hard substrata
0
10
20
40
Kilometers
Data Source:
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
Sandeel Spawning Grounds relative to the Fish and Shellfish Study Area
VER
DATE
REMARKS
Drawn
Checked
1
26/01/2024
For Information
BPHB
AL
DRAWING NUMBER:
6.8
SCALE: 1:1,250,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits

Sandeel Habitat Suitability Assessment

- 0 (Low)
- 2
- 3
- 4
- 5
- 6
- 7
- 9 (High)

0 10 20 40
Kilometers

Data Source:

PROJECT TITLE:

*FIVE ESTUARIES OFFSHORE WINDFARM*

DRAWING TITLE:

Sandeel Spawning Potential Heat Map

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Issue | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.9

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|

## SPECIES OF COMMERCIAL IMPORTANCE

6.7.22 Detailed information on species of commercial importance are provided in Volume 6, Part 2, Chapter 8: Commercial Fisheries, which identifies cockles (*Cerastoderma edule*), whelk (*Buccinum undatum*), seabass, plaice, thornback ray, red mullet, lobster horse mackerel and sole as key commercial species in the region.

6.7.23 Fisheries landings from 2016 to 2020 within the region were dominated by shellfish landings by both weight and value, with significant landings of cockles and whelk (MMO, 2020). Whelk fisheries are located along the east coast of the UK, with the highest fishing effort recorded in The Wash and North Norfolk. Various byelaws have been implemented by Kent & Essex Inshore Fisheries and Conservation Authorities (KEIFCA) to ensure the sustainable management of the whelk fisheries in the region for the benefit of fishermen, the local economy, and marine ecosystems alike. In addition, there are two main cockle fisheries located along the east coast; The Wash Fishery located to the north of VE, and the Thames Estuary fishery to the south of VE. A spawning herring fishery also lies within the Outer Thames estuary. However, following recent stock assessments identifying the spawning herring stocks as being below biomass limits, the fishery is currently closed (as of 31 January, 2022) to the regional fishing community (MMO, 2022b).

## MIGRATORY SPECIES

6.7.24 Migratory fish are fish that spend part of their life cycle in freshwater and part in seawater; such species are termed diadromous. The UK Salmon and Freshwater Fishery Act (1975) (amended) recognises three migratory species: Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*) and European eel (*Anguilla anguilla*).

6.7.25 There are a number of additional species known to migrate through the study area, of conservation interest and of relevance to VE. These include smelt (*Osmerus eperlanus*), river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) and two species protected under the Habitats Directive, the allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*).

## ELASMOBRANCHS

6.7.26 Elasmobranchs are the group of electrosensitive fish that includes sharks, rays and skates, and are therefore considered a sensitive receptor to electromagnetic fields (EMF) emitted from operational cables. The most abundant elasmobranch species recorded during fish surveys across the region were thornback ray, lesser spotted dogfish, tope shark, smoothhound and spurdog. In addition, tope and thornback ray also have nursery grounds present within the study area (Coull *et al*., 1998).

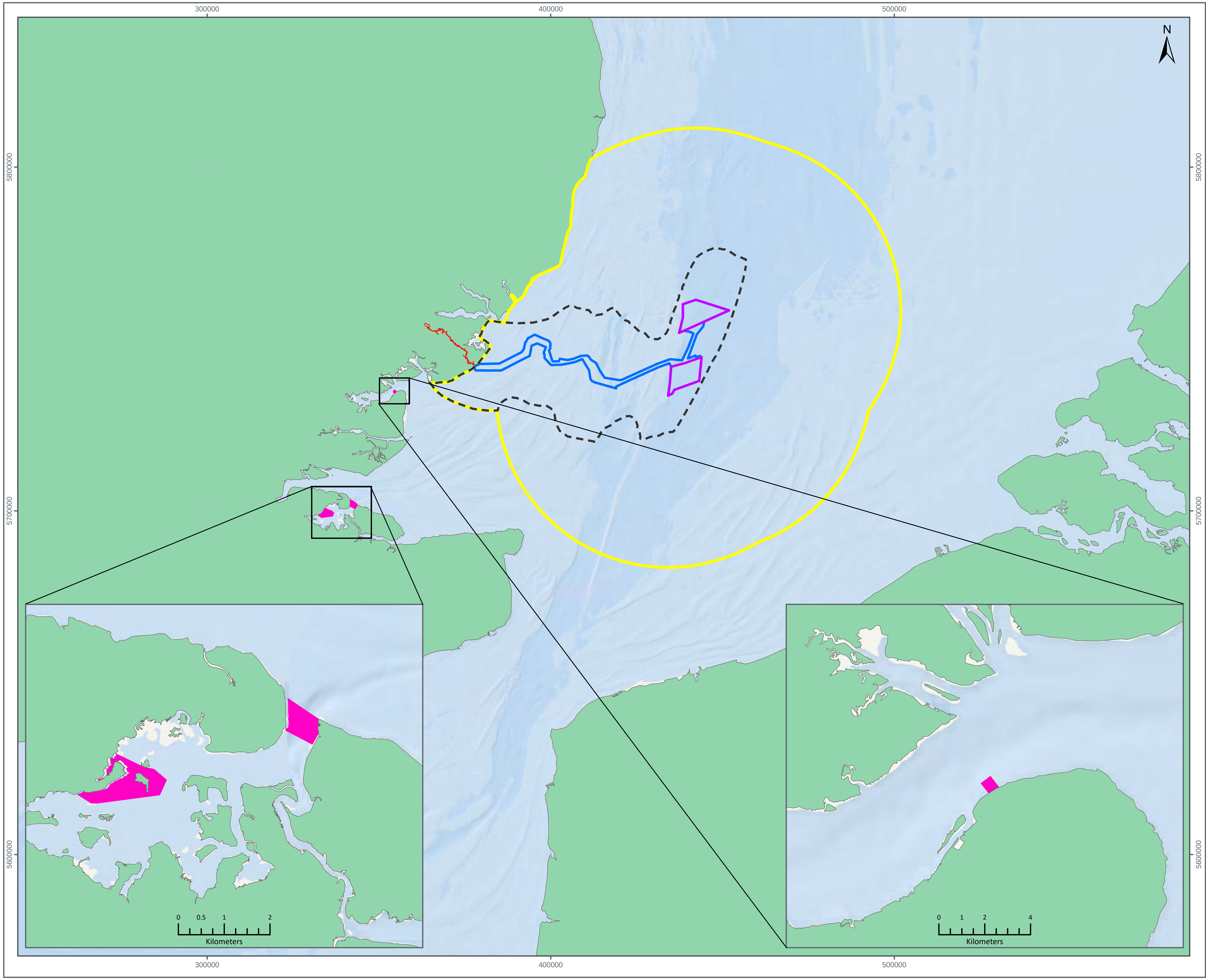
## SPECIES OF CONSERVATION IMPORTANCE

6.7.27 Several species of conservation importance have the potential to occur within the region, with the legislation under which each species is designated varying.

6.7.28 Those species which are designated under the Habitats Directive (among other legislation) are:

- Allis shad;
- Atlantic salmon;
- River lamprey;
- Sea lamprey;
- Twaite shad;
- European eel (designated under The Eels (England and Wales) Regulations 2009 (hereafter the Eels Regulations), and Eel Recovery Plan (Council Regulation No 1100/2007); and
- Seahorse (short snouted and long snouted seahorse) (Priority Species under the UK Post-2010 Biodiversity Framework and protected under the Wildlife and Countryside Act 1981).

6.7.29 The Blackwater, Crouch, Roach and Colne Estuary Marine Conservation Zone (MCZ) lies 4 km from the VE offshore ECC and is designated for native oyster (*Ostrea edulis*) and native oyster beds (Figure 6.11).The Southern North Sea SAC is designated for harbour porpoise (*Phocoena phocoena*), of which herring and sandeel are key prey species (Figure 6.11).




LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Sea Bass Nursery Grounds (Cefas, 1999)

0 10 20 40
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

*FIVE ESTUARIES OFFSHORE WINDFARM*

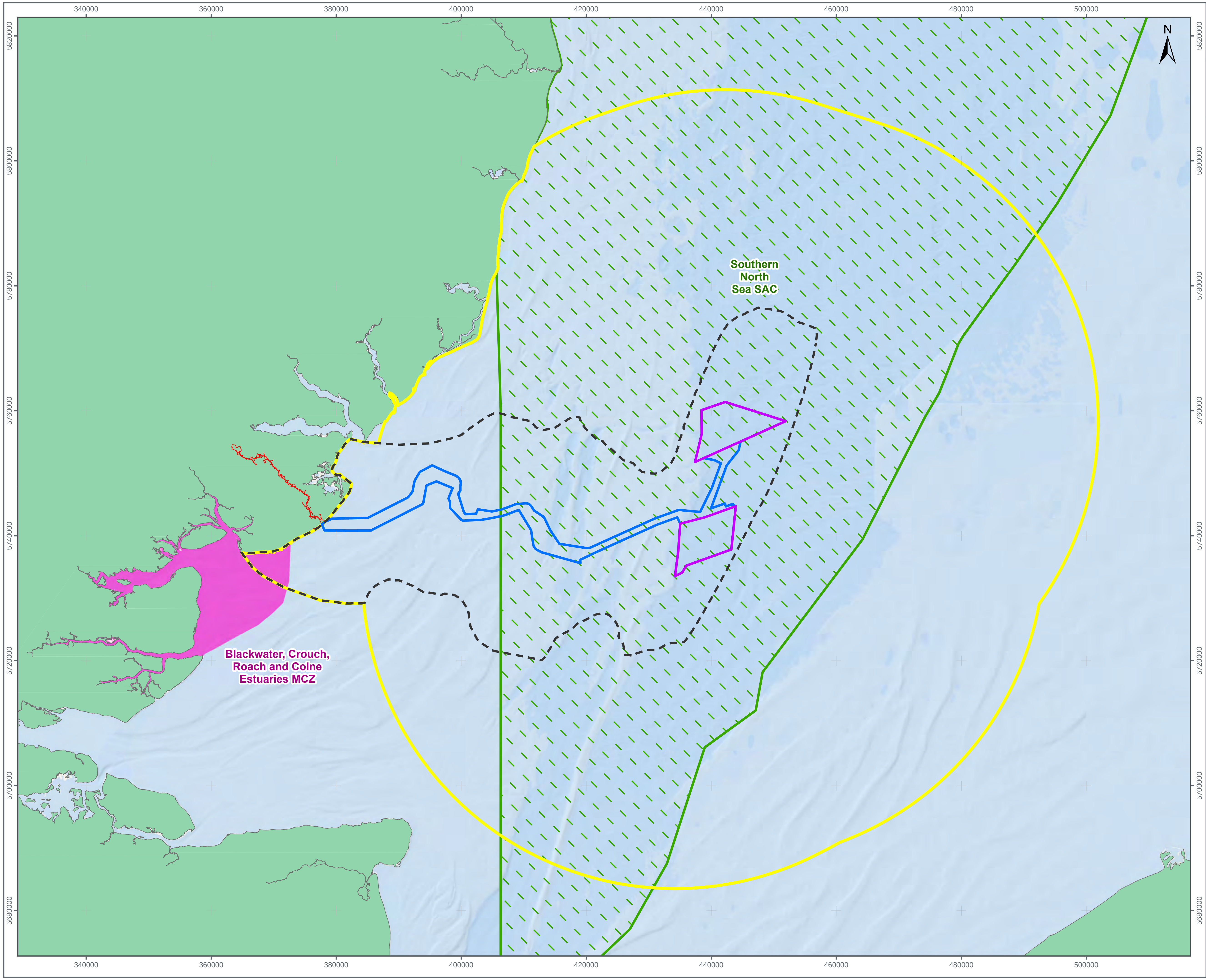
DRAWING TITLE:

Sea Bass Nursery Areas

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.10

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|




LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Special Areas of Conservation
- Marine Conservation Areas

0 5 10 20
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Designated Sites

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.11

SCALE: 1:550,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

## VALUED ECOLOGICAL RECEPTORS

6.7.30 To summarise the above, Table 6.9 below details the Valued Ecological Receptors (VERs) identified within Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report to be brought forward into the assessment. See Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, for detailed justification for the identification of the VER within Table 6.9.

**Table 6.9: Fish and Shellfish VERs.**

| VER Group | VERs |
|---|---|
| Demersal Fish | Brill, cod, dab, flounder, lemon sole, plaice, red mullet, sole, tub gurnard, turbot, whiting. |
| Migratory species | Atlantic salmon, European eel, allis shad, twaite shad, river lamprey, sea lamprey, sea trout, smelt. |
| Pelagic Fish | Bluefin tuna, sprat, mackerel, horse mackerel, sea bass. |
| Benthopelagic Fish | Sandeel, herring. |
| Shellfish | Nephrops, cockle, common whelk, king and queen scallop, native oyster, European lobster, brown crab. |
| Elasmobranchs | Blonde ray, cuckoo ray, lesser spotted dogfish, thornback ray, tope, small eyed ray, smoothhound, spotted ray, spurdog and velvet belly lanternshark. |

## EVOLUTION OF THE BASELINE

6.7.31 The current baseline description provides an accurate reflection of the current state of the existing environment. The main offshore construction works are anticipated to commence in 2029, with some preliminary survey and clearance works potentially taking place in 2028 and 2027, and therefore there exists the potential for the baseline to evolve between the time of assessment and point of impact. Outside of short-term or seasonal fluctuations, changes to the baseline in relation to fish and shellfish ecology usually occur over an extended period of time. Based on current information regarding reasonably foreseeable events over the next four years, the baseline is not anticipated to have fundamentally changed from its current state at the point in time when impacts occur. The baseline environment for operational/ decommissioning impacts is expected to evolve as described in the next section, with the additional consideration that any changes during the construction phase will have altered the baseline environment to a degree as set out in this chapter.

6.7.32 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "*an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge*" is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of VE, long-term trends mean that the condition of the baseline environment is expected to evolve. This section provides a qualitative description of the evolution of the baseline environment, on the assumption that VE is not constructed, using available information and scientific knowledge of fish and shellfish ecology.

6.7.33 Recent research has suggested that there have been substantial changes in the fish communities in the northeast Atlantic over several decades as a result of a number of factors including climate change and fishing activities (DECC, 2016). These communities consist of species that have complex interactions with one another and the natural environment. Fish and shellfish populations are subject to natural variations in population size and distributions, largely as a result of year-to-year variation in recruitment success and these population trends will be influenced by broad-scale climatic and hydrological variations, as well as anthropogenic effects such as climate change (see Section 6.15) and overfishing.

6.7.34 Fish and shellfish play a pivotal role in the transfer of energy from some of the lowest to the highest trophic levels within the ecosystem and serve to recycle nutrients from higher levels through the consumption of detritus. Consequently, their populations will be determined by both top-down factors such as predation, and bottom-up factors such as ocean climate and plankton abundance. Fish and shellfish are important prey items for top marine predators including elasmobranchs, seabirds and cetaceans, and small planktivorous species such as sandeel and spawning herring act as important links between zooplankton and top predators (Frederiksen, *et al*., 2006).

6.7.35 Climate change influences fish distribution and abundance, affecting growth rates, recruitment, behaviour, survival and response to changes of other trophic levels (Prakash and Srivastava, 2019). Climate change is contributing to the declining levels of primary production in the North Sea which in turn effects the dynamics of higher trophic levels and fish recruitment (Capuzzo *et al.,* 2018). Projected warming scenarios indicated regime shifts between sandeels and their copepod prey, resulting in sandeel recruitment declines (Regnier *et al.,* 2019). Increased sea surface temperatures in the North Sea may lead to an increase in the relative abundance of species associated with more southerly areas. For example, data on spawning herring and sardine *Sardina* spp. landings at ports in the English Channel showed that higher spawning herring landings were correlated with colder winters, while warm winters were associated with large catches of sardine (Alheit and Hagen, 1997).

6.7.36 One potential effect of increased sea surface temperatures is that some fish species will extend their distribution into deeper, colder waters. In these cases, however, habitat requirements are likely to become important, with some shallow water species having specific habitat requirements in shallow water areas which are not available in these deeper areas. For example, sandeel is less likely to be able to adapt to increasing temperatures as a result of its specific habitat requirements for coarse sandy sediment and declining recruitment in sandeel in parts of the UK has been correlated with increasing temperature (Heath *et al*., 2012). Climate change may also affect key life history stages of fish and shellfish species, including the timing of spawning migrations (BEIS, 2016). However, climate change effects on marine fish populations are difficult to predict and the evidence is not easy to interpret and therefore it is difficult to make accurate estimations of the future baseline scenario for the entire lifetime of the VE project (further detailed in Section 6.15).

6.7.37 In addition to climate change, overfishing subjects the populations of many fish species to considerable pressure, reducing the biomass of commercially valuable species, and non-target species. Overfishing can reduce the resilience of fish and shellfish populations to other pressures, including climate change and other anthropogenic impacts. For example, a study on cod in an area where trawl fishing has been banned since 1932 indicated that this population was significantly more resilient to environmental change (including climate change) than populations in neighbouring fished areas (Lindegren *et al*., 2010). Modelling by Beggs *et al*., (2013) indicated that cod may be more sensitive to climate variability during periods of low spawning stock biomass.

6.7.38 There are indications that overfishing in UK waters is reducing in the North Sea. The recent International Council for the Exploration of the Sea (ICES) Greater North Sea Ecoregion Ecosystem Overview reported declines in fishing mortality estimates in recent years for shellfish, demersal and pelagic stock groups, with spawning-stock biomass increased to above or close to the biomass reference points used in stock assessments of most stocks in the Greater North Sea (ICES, 2021). Should these improvements continue, this may not result in significant changes in the species assemblage in the Greater North Sea fish and shellfish study area, although may result in increased abundances of the characterising species present in the area.

6.7.39 It should be noted that there is also uncertainty surrounding the withdrawal of the

UK from the EU, with the UK now an independent coastal state and in control of waters out to 200 nautical miles (nm) and the long-term arrangements regarding access of non-UK vessels to UK Exclusive Economic Zone (EEZ) waters. Should long-term access rights follow historic fishing patterns continue, then the future baseline will remain consistent with the current baseline assessment. Otherwise, effort across the VE commercial fisheries study area is likely to be dominated by UK vessels with a corresponding reduction in effort by vessels from other EU member states.

6.7.40 The VE fish and shellfish baseline characterisation described in the preceding sections (and presented in detail in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) represents a ‘snapshot’ of the fish and shellfish assemblages of the North Sea, within a gradual and continuously changing environment. Any changes that may occur during the lifetime of VE (i.e., construction, operation and decommissioning) are considered in the context of the natural variability and other existing anthropogenic effects, including climate change and overfishing.

## 6.8 KEY PARAMETERS FOR ASSESSMENT

6.8.1 This section identifies the MDS of relevance to the assessment of impacts on fish and shellfish ecology, defined by VE design envelope (Volume 6, Part 2, Chapter 1: Offshore Project Description). The method adopted is in accordance with the requirements of the Rochdale Envelope approach to environmental assessment as set out in the PINS Advice note nine: 'Using the Rochdale Envelope' (PINS, 2018), and as detailed in Volume 6, Part 1, Chapter 3: EIA methodology).

6.8.2 The MDSs assessed for fish and shellfish ecology features are described in Table 6.10. These are the parameters which are judged to give rise to the maximum levels of effect for the assessment undertaken, as set out in Volume 6, Part 2, Chapter 1: Offshore Project Description. Should VE be constructed to different parameters within the design envelope, then impacts would not be any greater than those set out in the MDS presented in Table 6.10. The nature and extent of the environmental impacts arising during decommissioning is assumed (for the purposes of this assessment) to be similar to (or likely less) than that described for the equivalent activities during the construction phase and have therefore been presented based on the worst-case construction impacts.

**Table 6.10: Maximum design scenario for VE alone.**

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| **Construction and Decommissioning[4]** | | |
| Impact 1: Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration | **Array areas:**<br>**Spatial MDS (for stationary receptors):**<br>The sequential installation of monopile foundations at multiple locations, using a staggered approach. Two monopile foundations installed at both the Northern Array – N edge and Southern Array – SW corner.<br>Maximum hammer energy - 7,000 KJ (Kilojoule)<br>79 monopiles (15 m diameter)<br>2 OSP monopile foundations (15 m diameter)<br>592.5 hours piling (7.5 hours per monopile)<br>Or<br>The concurrent piling of monopile foundations at multiple locations.<br>Two monopiles installed sequentially at both the southern array area-SW corner and the northern array area-north edge. | For the array area, the spatial MDS for stationary receptors results from the sequential or concurrent piling of monopiles for 79 WTGs and 2 OSPs, using 7,000 KJ hammer energy. This would result in the largest spatial noise impact at any given time when considering impacts to stationary receptors.<br>For the array area, the spatial MDS for fleeing receptors results from the concurrent piling of monopiles for 79 WTGs and 2 OSPs, using 7,000 KJ hammer energy. This would result in the largest spatial noise impact at any given time when considering impacts to fleeing receptors.<br>The temporal MDS for the array area would be associated with the piling of pin piles for 79 WTGs, and two OSPs |

[4] The maximum design scenarios within this table represent construction in reverse for decommissioning.

| Potential effect | Maximum design scenario assessed | Justification |
| --- | --- | --- |
| | Maximum hammer energy - 7,000 kJ (Kilojoule)<br>79 monopiles (15 m diameter)<br>2 OSP monopile foundations (15 m diameter)<br>592.5 hours piling (7.5 hours per monopile)<br>**Spatial MDS (for fleeing receptors):**<br>Concurrent piling of monopiles (see above)<br>**Temporal MDS (for stationary and fleeing receptors):**<br>The sequential installation of pin pins for jacket foundations<br>Total 340 pin piles<br>> 79 small WTGs on piled jacket foundations (four 3.5 m diameter pin piles per jacket) –316 pin piles<br>> Two Offshore Substation Platform (OSP) foundations (six 3.5 m diameter pin piles per jacket) –24 pin piles<br>Maximum hammer energy of 3,000 kJ<br>Four hours piling duration per pile<br>1,360 hours of piling<br>**Array areas and offshore ECC** | using 3,000 kJ hammer energy. Total of 1,360 hours of piling across the whole project within a one-year construction window. |

| Potential effect | Maximum design scenario assessed | Justification |
| --- | --- | --- |
| | **UXO clearance:**<br>Estimated 2,000 targets;<br>60 UXO may require clearance; and<br>Up to 2 clearance events within 24 hours.<br>**Offshore ECC**<br>Piling of sheet pile exit pits:<br>Installation of 660 sheet piles using percussive drilling in the shallow subtidal<br>750 mm wide sheets<br>Piling of eight piles within a 24 hour period<br>Maximum hammer energy of 300 kJ | |
| Impact 2: Temporary increase in SSC and sediment deposition | **Total sediment volume released on Order Limits = 42,960,742 m$^3$**<br>**<u>Array areas</u>**<br>**Total sediment volume suspended in array areas = 32,728,589 m$^3$**<br>Seabed preparation for foundations = 1,193,600 m$^3$<br>79 small GBS (WTG) foundations = 1,137,600 m$^3$;<br>2 GBS foundations for OSP = 56,000m$^3$ | The MDS for foundation installation results from the largest volume suspended from seabed preparation and presents the worst-case for WTG installation. For cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also assumes the largest number of cables and the greatest burial depth.<br>The MDS for foundation installation results from the largest volume |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | Drill arisings from foundation installation = 563,223m$^3$<br>79 small steel monopile WTG foundations = 536,080m$^3$ (assumes 50% of locations are drilled)<br>2 OSP monopile foundations = 27,143m$^3$<br>Cable trenching = 3,150,000 m$^3$<br>Installation of 200 km of inter-array cables by mass flow excavator (MFE) resulting in the suspension of 3,150,000 m$^3$ of sediment<br>Sandwave clearance for cable installation= 22,795,580 m$^3$<br>Sandwave clearance for 150 km of array cables resulting in the suspension of 22,795,580 m$^3$ of sediment<br>JUV and anchoring operations = 4,686,000 m$^3$<br>JUV disturbance volumes for WTG and OSP installation in the array = 8,316,000 m$^3$<br>Anchor disturbance volumes WTG and OSP installation in array area = 1,516,320 m$^3$<br>Anchor disturbance volumes for inter-array cables= 374,693 m$^3$ | suspended from seabed preparation and presents the worst-case for WTG installation. For cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also assumes the largest number of cables and the greatest burial depth.<br>The MDS for temporary habitat disturbance in the intertidal area from the HDD works is included.<br>The maximum volume of bentonite which could be released as part of the landfall activities is considered. For this assessment, it is considered that the bentonite would not be captured and is released into the marine environment. |

| Potential effect | Maximum design scenario assessed | Justification |
| --- | --- | --- |
| | <u>**Offshore ECC**</u><br>**Total sediment volume suspended in offshore ECC = 10,487,073 $m^3$**<br>Sandwave clearance for cable installation = 6,988,922 $m^3$<br>Sandwave clearance for 98 km of export cables resulting in the suspension of 6,968,922 $m^3$ of sediment.<br>Seabed preparation for export cable vessel laydown areas = 57,600 $m^3$<br>Seabed preparation for 8 vessel laydown areas resulting in suspension of 57,600 $m^3$ of sediment.<br>Cable trenching = 3,079,125 $m^3$<br>Installation of 196 km of export cables by mass flow excavator resulting in the suspension of 3,079,125 $m^3$ of sediment.<br>JUV and Anchor disturbance volumes in ECC (ECC installation)= 363,906 $m^3$<br>**Intertidal sediment volume = 17,520 $m^3$**<br>Three offshore HDD exit pits require excavation which will be side-cast onto the adjacent seabed. Backfilling of exit pits will recover a similar amount from the surrounding seabed, as required. It has | |

| Potential effect | Maximum design scenario assessed | Justification |
| --- | --- | --- |
| | not been confirmed whether exit pits will occur in the subtidal or intertidal.<br>Maximum volume of drilling fluid that is expected to be released from the HDD into the intertidal/subtidal = 14,820 $m^3$<br>> Indicative maximum volume of cuttings expected to be released from the HDD into the intertidal / subtidal = 2,700 $m^3$ | |
| Impact 3: Direct and indirect seabed disturbances leading to the release of sediment contaminants | The MDS for the maximum volumes of seabed sediment disturbance are presented in **Impact 2.** | This scenario represents the maximum total seabed disturbance and therefore the maximum amount of contaminated sediment that may be released into the water column during construction activities. |
| Impact 4: Impacts on fishing pressure due to displacement | 500 m safety zones around infrastructure that is under construction.<br>Temporary safety zones of 50 m will be implemented around incomplete structures such as installed monopiles without transition pieces, or where construction works are completed but commissioning has yet to be completed. | This scenario represents the area of safety zones implemented during works, and therefore the maximum area of fishing activity displacement. Displacement of fishing activity has the potential to lead to increased pressure from fishing on fish and shellfish populations outside of the safety zones. |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| Impact 5: Direct damage (e.g. crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities | **Total temporary habitat disturbance within Order Limits = 36,513,188 m²**<br>**<u>Array areas:</u>**<br>**Total temporary habitat disturbance within array areas = 21,771,734 m²**<br>Foundation seabed preparation = 298,400 m²<br>Seabed preparation for 79 small Gravity Base Structure (GBS) (Wind Turbine Generator (WTG)) foundations for WTG = 284,400 m²;<br>Seabed preparation for 2 GBS foundations for Offshore Substation Platform (OSP) = 14,000 m²; and<br>Areas impacted by placement of gravel bed would be within the footprint of the seabed preparation and so are not considered to be additive.<br>Jack-up vessels (JUV) and anchoring operations = 1,183,275m²<br>Seabed disturbance per jacking-up operation = 1,100 m²<br>504 JUV operations (6 operations per WTG (70 WTGs), 2 jacking-up operations per accommodation vessels (2 vessels) and commissioning vessels (3 vessels)). | The subtidal direct damage temporary disturbance relates to seabed preparation for foundations and cables, jack up and anchoring operations, and cable installation. It should be noted that where boulder clearance overlaps with sandwave clearance, the boulder clearance footprint will be within the sandwave clearance footprint.<br>The MDS for direct damage in the intertidal area from the HDD works is included. |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | Total JUV impact area for WTG and OSP installation in the array = 554,400 $m^2$<br><br>Anchor footprints for WTG and OSP installation (inclusive of topside installation) = 379,080$m^2$<br><br>Anchor footprints- array cable installation= 249,795$m^2$<br><br>Cable seabed preparation and installation in the array areas = 20,290,059 $m^2$<br><br>100% of the inter-array cable route may require boulder clearance<br><br>Total area of seabed disturbed by boulder clearance for inter-array cables = 900,000 $m^2$<br><br>100% of the inter-array cable route may require pre-lay grapple run.<br><br>Total area of seabed disturbed by pre-lay grapple run is = 6,000,000 $m^2$ (as this area overlaps it has only been calculated once to form the total)<br><br>75% of the inter-array cable route may require sandwave clearance<br><br>Total area of seabed disturbed by sandwave clearance of inter-array cable routes= 10,690,059 $m^2$ | |

| Potential effect | Maximum design scenario assessed | Justification |
| --- | --- | --- |
| | Total area of seabed disturbed by burial of inter-array cables (total length 200 km length) = 3,600,000 $m^2$<br>**<u>Offshore ECC:</u>**<br>**Total temporary habitat disturbance within Offshore ECC = 14,739,204 $m^2$**<br>Cable seabed preparation and installation in the offshore ECC = 14,439,000 $m^2$<br>100% of the export cable route may require boulder clearance<br>Total area of seabed disturbed by boulder clearance for export cables = 879,750 $m^2$<br>100% of the export cable route may require pre-lay grapnel run<br>Total area of seabed disturbed by pre-lay grapple run is = 5,865,000 $m^2$ (as this area overlaps with boulder clearance it has only been calculated once to form the total)<br>50% of the export cable route may require sandwave clearance<br>Total area of seabed disturbed by sandwave clearance = 5,054,000 $m^2$ | |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | Burial of export cables (total length 195.5 km length per cable) = 3,520,000 $m^2$<br><br>The seabed footprint for cable jointing is within the design envelope for seabed preparation and cable installation.<br><br>JUV and anchoring operations = 242,604 $m^2$<br><br>Seabed preparation for export cable vessel laydown areas = 57,600 m2<br><br>Seabed preparation for 8 vessel laydown areas resulting in disturbance of 57,600 $m^2$ of sediment.<br><br>Temporary intertidal habitat disturbance = 2,250 $m^2$<br><br>Temporary habitat disturbance from horizontal directional drilling (HDD) exit pit excavation within the intertidal (or shallow subtidal):<br><br>HDD pits will be in either the intertidal or below lowest astronomical tide;<br><br>Stage 1: Up to 3 HDD exit pits (10 m width x 75 m length x 2.0-2.5 m depth) excavated via backhoe dredge (or similar) with material side-cast for backfill;<br><br>Stage 2: Once the ducts are in place, the exit pits will likely be temporarily backfilled until ready for cable pull-through. The ducts will then need to be re-exposed to pull in the cable; and | |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | Any inter-tidal cable installation is captured within the MDS for the installation of export cables in the offshore ECC. | |
| Impact 6: Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors | Synthetic compound, heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation and a maximum of 4,311 round trips to port by construction vessels over the construction period. Water-based drilling muds associated with drilling to install foundations, should this be required.<br>Potential contamination of intertidal habitats resulting from machinery use and vehicle movement.<br>Potential contamination of intertidal habitats from drilling mud,(e.g. bentonite) used to facilitate the installation of export cables via trenchless installation techniques (e.g. horizontal directional drilling (HDD), thrust boring, auger boring or pipe ramming).<br>Total volume of drilling mud released = 14,820 $m^3$ | These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction. |
| Impact 7: Temporary habitat loss | The MDS for seabed disturbance are presented in **Impact 5**. | This scenario represents the maximum total seabed disturbance and therefore the maximum amount of temporary habitat loss. |
| **Operation** | | |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| Impact 8: Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration | **<u>Array areas:</u>**<br>Underwater noise during the operational phase from 79 small WTGs and maintenance vessel operations over the design lifetime of VE (i.e., up to 40 years). | Maximum number of operational WTGs and related Operation and Maintenance visits by vessels during the lifetime of the project. |
| Impact 9: Temporary increase in SSC and sediment deposition | **Total subtidal sediment volume = 655,609 $m^3$**<br>**<u>Array areas:</u>**<br>Array cable repair/replacement:<br>8 cable repair/replacement events, with a maximum disturbance of 53,762 $m^3$ per event = 430,096 $m^3$ over lifetime of project<br>**<u>Offshore ECC</u>**<br>Export cable repairs<br>9 cable repair/replacement events, with a maximum disturbance of 25,057 $m^3$ per event = 225,513 $m^3$ | The MDS for temporary increases in SSC and deposition results from the largest volume suspended from cable repair works during the O&M phase of development. |
| Impact 10: Impacts on fishing pressure due to displacement | **<u>Array areas and offshore ECC</u>**<br>Temporary 500 m safety zones around infrastructure that is undergoing major maintenance (for example a WTG blade replacement) will be implemented. | This scenario represents the area of safety zones implemented during works, and therefore the maximum area of fishing displacement. |
| Impact 11: Long-term or permanent loss of habitat due to the presence of WTGs | **Total habitat loss within Order Limits 3,545,465 $m^2$** | The MDS is defined by the maximum area of seabed lost as a result of the placement of structures, scour |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| foundations, scour protection and cable protection | **<u>Array Areas</u>**<br>**Total habitat loss within array areas = 3,242,461 m$^2$**<br>> Turbine total structure footprint including scour protection, based on 79 GBS (WTG-type) foundations = 1,313,537 m$^2$<br>> OSP total structure footprint including scour protection, based on two GBS monopile foundations = 81,656 m$^2$<br>> It is assumed that up to 20% of scour protection may be replaced over the lifetime of VE (Total scour area for all foundations = 1,395,268 m$^2$<br>> Maximum array cable rock berm protection = 321,600 m$^2$<br>> Total of 13 cable crossings associated with inter-array cables. Footprint of crossing protection material (rock berms and mattresses) = 103,400 m$^2$<br>**<u>Offshore ECC</u>** | protection, cable protection and cable crossings. The MDS also considers that scour protection is required for all foundations. Habitat loss from drilling and drill arisings is of a smaller magnitude than presence of project infrastructure. |

| Potential effect | Maximum design scenario assessed | Justification |
| --- | --- | --- |
| | **Total habitat loss within offshore ECC = 303,004 m$^2$**<br>> Total area of seabed covered by rock berm cable protection (10% of export cables) = 178,304 m$^2$<br>> Removable cable protection (if required) within the Margate and Long Sands SAC = 5,400 m$^2$ (6 m width protection over 900 m)<br>> Total of 30 cable crossings associated with export cables. Footprint of crossing protection material (rock berms and mattresses) = 119,300 m$^2$ | |
| Impact 12: Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection | **Total surface area of introduced hard substrate in the water column within the Order Limits = 2,038,259 m$^2$**<br>**Array areas**<br>Total area of introduced hard substrate at seabed level = 3,242,461 m$^2$ (see **Impact 11**)<br>Total surface area of subsea portions of foundations in contact with the water column: 236,662 m$^2$ | Maximum scenario for introduced hard substrate is as for the maximum scenario for loss of habitat. |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | > 79 GBS (WTG-type) foundations, with a total surface area of 223,262 $m^2$<br>> OSP structure area, based on two GBS monopile foundations, assuming, with a total surface area of 13,400 $m^2$<br>**Offshore ECC**<br>> Total area of introduced hard substrate at seabed level = 303,004 m2 (see Impact 11) | |
| Impact 13: EMF effects arising from cables during operational phase | **Inter-array cables**<br>> Up to 200 km of inter-array cable, operating up to 132 kV<br>> Inter-array cable depth = 0 – 3.5 m<br>**Offshore export cables**<br>> Up to 196 km of export cable, operating up to 275 Kv<br>Export cable depth = 0 – 3.5 m | The maximum design scenario is associated with the use of 79 WTGs as this results in the greatest length of inter-array cable and export cables as this results in the longest total length of cable. |
| Impact 14: Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from O&M activities | **Total direct disturbance to seabed within Order Limits= 734,894$m^2$**<br>**Array areas** | Defined by the maximum number of jack-up vessel operations and maintenance activities that could have an interaction with the seabed anticipated during operation. |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | **Total direct disturbance within array areas in Project lifetime: 589,052m$^2$**<br>Major component replacement events for WTG's and platforms (jacking-up activities)<br>Seabed disturbance per jacking-up event = 1,100 m$^2$<br>Maximum number of major component replacement events for WTG's and platforms (jacking-up activities) during Project lifetime= 284<br>Total seabed disturbance by jacking-up activities through Project lifetime = 312,400 m$^2$<br>Array cable repairs<br>Total seabed disturbance for array cable repairs per event= 25,057 m$^2$ (8 array cable repairs in project lifetime)<br>Additional seabed disturbance area to be considered for array cable repairs carried out by vessel utilising anchors per repair = 34,582 m$^2$ (8 array cable repairs in project lifetime)<br>Total seabed disturbed by array cable repairs through Project lifetime = 276,652 m$^2$<br>**<u>Offshore ECC</u>**<br>Total direct disturbance within Offshore ECC in Project lifetime = 145,842 m$^2$ | |

| Potential effect | Maximum design scenario assessed | Justification |
|---|---|---|
| | Export cable repairs<br>Seabed disturbance for export cable repairs per event= 10,000 $m^2$ (9 export cable repairs in Project lifetime)<br>Additional seabed disturbance to be considered for export cable repairs carried out by vessel utilising anchors per repair= 6,205 $m^2$ (9 export cable repairs in Project lifetime)<br>Total direct disturbance in Project lifetime = 145,842 $m^2$ | |
| Impact 15: Accidental pollution events during the operation and maintenance phase resulting in potential effects on fish and shellfish receptors | Synthetic compound, heavy metal and hydrocarbon contamination resulting from a maximum of 1,776 annual round trips to port by construction vessels over the O&M period. | These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction. . |
| Impact 16: Temporary habitat loss/physical disturbance | The MDS for seabed disturbance are presented in Impact 14. | Defined by the maximum number of jack-up vessel operations and maintenance activities that could have an interaction with the seabed anticipated during operation. |

## 6.9 MITIGATION

6.9.1 The mitigation contained in Table 6.11 are mitigation measures or commitments that have been identified and adopted as part of the evolution of the project design of relevance to the topic, these include project design measures, compliance with elements of good practice and use of standard protocols.

**Table 6.11: Mitigation relating to fish and shellfish ecology.**

| Project phase | Mitigation measures |
|---|---|
| **General** | |
| Project design | The development boundary selection was made following a series of constraints analyses, with the array area and offshore ECC route selected to ensure the impacts on the environment and other marine users are minimised as far as reasonably practicable. |
| Pollution prevention | A PEMP is proposed to be produced to ensure that the potential for contaminant release is strictly controlled. The PEMP will include a MPCP and will also incorporate plans to cover accidental spills, potential contaminant release and include key emergency contact details (e.g., Environment Agency (EA), Natural England, Maritime Coastguard Agency (MCA) and the project site co-ordinator). The Outline PEMP (Volume 9, Report 18) will be secured as a condition in the deemed Marine Licence(s).<br>Typical measures will include:<br>Storage of all chemicals in secure designated areas with impermeable bunding (generally to 110% of the volume); and<br>Double skinning of pipes and tanks containing hazardous materials.<br>The purpose of these measures is to ensure that potential for contaminant release is strictly controlled and provides protection to marine life across all phases of the life of the wind farm. |
| Pollution prevention | The Applicant commits to the disposal of sewage and other waste in a manner which complies with all regulatory requirements, including but not limited to the IMO MARPOL requirements[5]. |
| **Construction** | |
| Cable Specification and Installation Plan (CSIP) | Development of and adherence to, a Cable Specification and Installation Plan (CSIP), relating to the offshore ECC, post consent. The CSIP will set out appropriate cable burial depth in accordance with industry good practice, minimising the risk of cable exposure. |

[5] https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx

| Project phase | Mitigation measures |
|---|---|
| | The CSIP will also ensure that cable crossings are appropriately designed to mitigate environmental effects, these crossings will be agreed with relevant parties in advance of CSIP submission. The CSIP will be conditioned in the deemed Marine Licence. An Outline CSIP has been provided as part of this DCO Application (Volume 9, Report 12). |
| Cable Burial Risk Assessment (CBRA) | A detailed CBRA to enable informed judgements regarding burial depth to maximise the chance of cables remaining buried whilst limiting the amount of sediment disturbance to that which is necessary. An outline CBRA is provided within Volume 9, Report 9. |
| Project design | A Marine Mammal Mitigation Protocol (MMMP) protocol for pilling and UXO will be developed in accordance with the Outline MMMP (Volume 9, Report 14.1 and 14.2 respectively) and will be implemented during construction. The piling MMMP will include details of soft starts and ramp up procedures to be used during piling operations. |
| **Operation** | |
| Project design | Where burial depth cannot be achieved, cable armouring will be implemented (e.g., mattressing, rock placement etc). The suitability of installing rock or mattresses for cable protection will be investigated, based on (inter alia) the seabed current data at the location of interest and the assessed risk of impact damage and navigational water depth requirements. |
| Project design | In areas where there is potential for unacceptable scour pits to develop around the foundations of structure, then scour protection will be implemented. |
| **Decommissioning** | |
| Decommissioning Programme | A Decommissioning Programme will be developed to cover the decommissioning phase as required under Chapter 3 of the Energy Act 2004. As the decommissioning phase will be a similar process to the construction phase but in reverse (i.e., increased project vessels on-site, partially deconstructed structures) the mitigation measure will be similar to those for the construction phase. The Decommissioning Programme is a requirement of the DCO. |

## 6.10 ADDITIONAL MITIGATION

6.10.1 The mitigation measures summarised in Table 6.12 are measures that have been proposed following the assessment of impacts on fish and shellfish ecology as undertaken in Sections 6.11, 6.12, 6.13 and 6.14, and the conclusion of potential significant effects on fish and shellfish populations.

**Table 6.12: Additional mitigation relating to fish and shellfish ecology.**

| Project phase | Mitigation measures |
|---|---|
| **Construction** | |
| Seasonal piling restriction | No piling within the array areas will be undertaken during the peak Downs herring spawning period. The Applicant considers that that a peak spawning period which has been defined from 6 November until 1 January is appropriate to avoid population impacts on herring. Specific details can be found in Volume 6, Part 5, Annex 6.4: Herring Seasonal Restriction Note. |
| Sediment disposal restriction | Dredge material from the northern array area will not be disposed of within the southern array area, to ensure sediment characteristics of the southern array area are maintained. See Volume 9, Report 8: Dredge Disposal Characterisation Report for further detail. |

## 6.11 ENVIRONMENTAL ASSESSMENT: CONSTRUCTION

6.11.1 The potential environmental impacts arising from the construction of VE are listed in Table 6.10 along with the MDS against which each construction phase impact has been assessed. A description of the potential effect on fish and shellfish ecology receptors caused by each identified impact is given below.

6.11.2 The current project design includes an offshore ECC to shore to facilitate power export from the Array Areas to the national electricity grid. Under the Offshore Transmissions Network Review (OTNR) options, work to consider the potential for an offshore connection has been commenced but is not well advanced. An offshore connection is not a viable or deliverable alternative at this time. However, in order to allow the identification of impacts that be relevant were this to become an option, the assessment for each potential impact has been split into "Array Area Impacts" and "Offshore Export Cable Corridor Impacts." Further details on the OTNR process are outlined in Volume 9, Report 29: Offshore Connection Scenario.

### IMPACT 1: MORTALITY, INJURY, BEHAVIOURAL IMPACTS AND AUDITORY MASKING ARISING FROM NOISE AND VIBRATION

6.11.3 The assessment below focuses on underwater noise from pile-driving (pin piles and monopiles) for the installation of foundations for offshore structures (i.e., WTGs and OSS), cable installation (including sheet piling for drilling pits), vessel disturbance and UXO clearance.

6.11.4 To inform the assessment of potential impacts associated with underwater noise from the array areas as a result of the installation of foundations, predictive underwater noise modelling has been undertaken for the relevant piling MDSs', full details of which are presented in Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report.

6.11.5 To inform the assessment of the potential impacts associated with underwater noise as a result of UXO clearance, a high-level consideration has been provided of the potential effects arising from UXO clearance below. It should be noted that UXO clearance will be consented under a separate Marine Licence (post-consent) and will therefore not be consented under the DCO. Therefore, a high-level review has been undertaken.

6.11.6 The following provides further information on the definition of the MDS for underwater noise. As detailed in Table 6.10, several activities have the potential to introduce an effect receptor pathway for underwater noise. These can be broadly characterised as underwater noise associated with general seabed clearance, cable installation and vessel operations, underwater noise associated with foundation installation, and underwater noise associated with UXO specific seabed clearance.

6.11.7 General construction noise, arising from vessel movements, dredging and seabed preparation works will generate low levels of continuous sounds (i.e., from the vessels themselves and/or the sounds from dredging tools) throughout the construction phase. The study area is subject to high levels of shipping activity currently, and it is expected that the vessel activity would be no greater than the baseline during construction activities (due to construction exclusion zones reducing current shipping activity and the number of construction vessels expected to be much lower than that which currently transit the area). The underwater noise impacts from vessel noise are generally spatially limited to the immediate area around the vessel rather than having impacts over a wide area (e.g., Mitson, 1993).

6.11.8 The structure of the assessment of underwater noise impacts on fish and shellfish receptors is provided in Table 6.13 below:

**Table 6.13: Scope of underwater noise assessment**

| Step of assessment | Description |
|---|---|
| Identification of the spatial and temporal underwater noise MDS for piling within the array areas | The worst-case impacts from underwater noise will result from the piling of turbines. The maximum spatial and temporal design scenarios are defined. |
| Definition of Valued Ecological Receptors (VERs) sensitivities and injury criteria for assessment | VERs are categorised into sensitivity Groups (based on the Popper *et al*., (2014) criteria) based on their presence or absence of a swim bladder and involvement of the swim bladder in hearing. |
| Noise and vibration arising from the installation of WTG and OSP foundations within the array areas. | Modelling of underwater noise impacts from the installation of WTG and OSP foundations. |

| Step of assessment | Description |
| --- | --- |
| Assessment of mortality and potential mortal injury of VER groups | Assessment of impacts from underwater noise on the following groups as informed by underwater noise modelling (assessment of sensitivity, magnitude and significance of effect): Group 1 VERs; Group 2 VERs; Group 3 VERs; Eggs and larvae; Shellfish |
| Assessment of recoverable injury of VER groups | |
| Assessment of Temporary Threshold Shift (TTS) of VER groups | |
| Assessment of behavioural impacts of VER groups | |
| Noise and vibration arising from UXO clearance within the array areas and the offshore ECC. | Qualitative assessment undertaken, as the worst case MDS from the piling of turbine foundations is modelled. |
| Noise and vibration arising from the installation of sheet piled exit pits at landfall. | Modelling of underwater noise impacts from the installation of sheet piled exit pits. |

## ARRAY AREAS

6.11.9 Modelling of underwater noise impacts from the piling of WTG and OSP foundations (piling of monopiles or pin piles) has been undertaken in accordance with the maximum design scenarios, i.e., the maximum design parameters that may be utilised during the construction of the proposed development. Two foundation scenarios have considered:

- Monopile installation- 15 m diameter pile, with a maximum hammer energy of 7,000 kJ; and
- Pile-pile installation for jacket foundations- 3.5 m piles, with a maximum hammer energy of 3,000 kJ.

6.11.10 In this context it is important to note that the maximum hammer energies assumed in the MDS are likely to be precautionary and that in fact for many piling events, a lesser hammer energy will be required to complete the pile installation.

6.11.11 A ‘burst’ piling approach is proposed to be implemented when piling. The burst piling section is proposed to be implemented after the first 10 minutes of soft start and ramp up, with 30 seconds of piling, at 40 strikes per minute, followed by a pause of 30 seconds, which is repeated for 5 minutes. A summary of the soft start procedure is provided in Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol - Piling.

6.11.12 In a 24-hour period, there is the potential for up to four pin piles to be installed at a single WTG foundation location, and there is the possibility that two piling vessels will operate concurrently. This would result in a combined total of up to eight piles being installed in a day. Underwater noise modelling has therefore been undertaken for the sequential installation of pin pile foundations at a single location, and at multiple locations across the array areas using a staggered installation approach. The potential for concurrent piling of pin piles at multiple locations has also been considered. For monopile foundations, up to four foundations could be installed in a day. To inform the underwater noise modelling, it has been assumed that a piling vessel would move between adjacent WTG locations in a line, installing one monopile driven at each location. The potential for monopiles to be installed sequentially at multiple locations using a staggered approach has therefore been modelled, as well as concurrent piling of monopile foundations at multiple location.

6.11.13 For ease of reference, the maximum design parameters as relevant to piling in the array areas have been summarised from Table 6.10, and are presented in Table 6.14. The scenarios are detailed in full in Volume 6, Part 5, Annex 6.2: Underwater Noise Report.

6.11.14 The spatial MDS equates to the greatest area of effect from subsea noise at any one-time during piling of foundations. When regarding stationary receptors the spatial MDS results from the sequential, or concurrent piling of monopiles. For fleeing receptors, the spatial MDS results from the concurrent piling of monopile foundations with a ‘burst approach’.

6.11.15 The temporal MDS represents the longest duration of effects from subsea noise which is considered to result from the installation of pin piles in the array areas (See Table 6.14).

**Table 6.14: MDS for foundations installation in the array areas.**

| | Single Piling Scenario (single location) | Sequential Piling Scenario (single location) | | Sequential Piling Scenario at Multiple Locations (Southern array area-SW corner, Northern array area -North Edge) | | Concurrent Piling Scenario at Multiple Locations (Southern array area-SW corner, Northern array area-North Edge) | |
|---|---|---|---|---|---|---|---|
| | **Pin Pile Foundations** | **Monopile Foundations** | **Pin Pile Foundations** | **Monopile Foundations** | **Pin Pile Foundations** | **Monopile Foundations** | **Pin Pile Foundations** |
| **Spatial MDS** | | | | | | | |
| **Installation Approach** | Piling of 1 pin-pile within a 24-hour period (Table 6.17) | Piling of 1 monopile within a 24-hour period (Table 6.17) | Piling of 4 pin-piles within a 24-hour period at a single location (Table 6.17) | Monopiles installed sequentially – alternate staggered installation at the Northern Array – N edge and Southern Array – SW corner, with two monopiles installed at each location (four total piles) (Table 6.18) | Pin piles installed sequentially – installation of four piles (sequentially) at the Northern Array – N edge, followed on completion by the installation of four piles (sequentially) at the Southern Array – SW corner (eight | Monopiles installed concurrently at the southern array area-SW corner and the northern array area-north edge, with two piles installed sequentially at each location (four total piles) (Table 6.19) | Pin piles installed concurrently at the southern array area-SW corner and the northern array area-north edge, with four piles installed sequentially at each location (eight total piles) (Table 6.19) |

| | Single Piling Scenario (single location) | Sequential Piling Scenario (single location) | | Sequential Piling Scenario at Multiple Locations (Southern array area-SW corner, Northern array area -North Edge) | | Concurrent Piling Scenario at Multiple Locations (Southern array area-SW corner, Northern array area-North Edge) | |
|---|---|---|---|---|---|---|---|
| | | | | | total piles) (Table 6.18) | | |
| **Pile diameter** | 3.5m | 15 m | 3.5 m | 15 m | 3.5 m | 15 m | 3.5 m |
| **Hammer Energy (maximum)** | 3,000 kJ | 7,000 kJ | 3,000 kJ | 7,000 kJ | 3,000 kJ | 7,000 kJ | 3,000 kJ |
| Temporal MDS | | | | | | | |
| **Maximum Number of Piles** | 340 (79 WTGs, 2 OSPs) | 81 (79 WTGs, 2 OSPs) | 340 (79 WTGs, 2 OSPs) | 81 (79 WTGs, 2 OSPs) | 340 (79 WTGs, 2 OSPs) | 81 (79 WTGs, 2 OSPs) | 340 (79 WTGs, 2 OSPs) |
| **Maximum Piling Duration (hours)** | 1,360 hours (4 hours per pin pile). | 592.5 hours (7.5 hours per monopile). | 1,360 hours (4 hours per pin pile). | 592.5 hours (7.5 hours per monopile). | 1,360 hours (4 hours per pin pile). | 302.85 hours (7.5 hours per monopile). | 680 hours, 4 hours per pin pile). |

## RECEPTOR SENSITIVITY AND INJURY CRITERIA FOR ASSESSMENT

6.11.16 The following sections consider the potential sensitive receptors to underwater noise, and provide information regarding the agreed metrics and thresholds for assessment, followed by the assessment of the following effect-receptor pathways:

- Underwater noise associated with foundation installation;
  - Monopile installation MDS
  - Pin pile installation MDS
- Underwater noise associated with UXO clearance; and
- Underwater noise associated with the piling of sheet piles at the landfall.

6.11.17 Underwater noise can potentially have a negative impact on fish and shellfish species ranging from behavioural effects to physical injury/mortality. In general, biological damage as a result of sound energy is either related to a large pressure change (barotrauma) or to the total quantity of sound energy received by a receptor. Barotrauma injury can result from exposure to a high intensity sound even if the sound is of short duration (i.e., UXO clearance or a single strike of a piling hammer). However, when considering injury due to the energy of an exposure, the time of the exposure becomes important. Fish and shellfish are also considered to be sensitive to the particle motion element of underwater noise; an impact considered more important than sound pressure for many species, particularly invertebrates, such as shellfish.

6.11.18 For the purposes of the assessment, Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report presents the results of modelling for a range of noise levels, representing the MDS for the installation of both monopile and pin pile foundations. The modelling results for cumulative sound exposure level ($SEL_{cum}$) provide outputs for both fleeing receptors (with the receptors fleeing from the source at a consistent rate of 1.5 $ms^{-1}$), and stationary receptors to account for spawning activity for more static demersal spawners such as sandeel or herring, or eggs and larvae.

## INJURY CRITERIA

6.11.19 The fish VERs within the VE study area have been grouped into the Popper *et al*., (2014) categories based on their hearing system, as outlined in Table 6.15 below. It is important to note that there are differences in impact thresholds for the different hearing groups.

6.11.20 In the case of shellfish, there are no specific impact criteria; therefore, an assessment has been based on a review of peer-reviewed literature on the current understanding of the potential effects of underwater noise on shellfish species, with a focus on the potential implications of particle motion associated with underwater noise.

**Table 6.15: Hearing categories of fish receptors (Popper *et al.*, 2014).**

| Category | VERs Relevant to VE |
|---|---|
| Group 1 (least sensitive) | Sandeel, brill, flounder, turbot, common sole, lemon sole, dab, plaice, mackerel, horse mackerel, river and sea lamprey, elasmobranchs (blonde ray, cuckoo ray, lesser spotted dogfish, thornback ray, tope, small eyed ray, smoothound, spotted ray, spurdog, velvet belly lanternshark). |
| Group 2 | Atlantic salmon, sea trout, bluefin tuna |
| Group 3 (most sensitive) | Spawning herring, cod, seahorse, sprat, cod, whiting, European eel*, allis and twaite shad, smelt*, tub gurnard*, sea bass*. |

(* denotes uncertainty or lack of current knowledge with regards to the potential role of the swim bladder in hearing)

**Table 6.16: Impact Threshold Criteria from Popper *et al*., (2014).**

| | Impact Threshold Noise Level (dB re 1 µPA Sound Exposure Level (SEL)/dB re 1 µPA$^2$ Sound Exposure Level (SEL)) | | |
|---|---|---|---|
| | Mortality and Potential Injury | Recoverable Injury | TTS |
| Group 1 | 219 dB $SEL_{cum}$<br>213 dB $SPL_{peak}$ | 216 dB $SEL_{cum}$<br>213 dB $SPL_{peak}$ | >>186 dB $SEL_{cum}$ |
| Group 2 | 210 dB $SEL_{cum}$<br>207 dB $SPL_{peak}$ | 203 dB $SEL_{cum}$<br>207 dB $SPL_{peak}$ | >186 dB $SEL_{cum}$ |
| Group 3 | 207 dB $SEL_{cum}$<br>207 dB $SPL_{peak}$ | 203 dB $SEL_{cum}$<br>207 dB $SPL_{peak}$ | 186 dB $SEL_{cum}$ |
| Eggs and Larvae | 210 dB $SEL_{cum}$<br>207 dB $SPL_{peak}$ | N/A | N/A |

6.11.21 The noise modelling for injury ranges for fleeing and stationary fish is presented in Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report, and referred to, as appropriate in the following assessments. Table 6.17, Table 6.18 and Table 6.19 below summarise the results for each of the relevant criteria against the MDS under consideration.

**Table 6.17: Noise modelling results for injury ranges for fleeing and stationary receptors for piling at single locations**

| | | | Monopile Impact Ranges | | | Pin Pile Impact Ranges | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Piling of a single monopile in a 24-hour period | | | Piling of a single pin pile in a 24-hour period | | | Sequential piling of up to four pin piles in a 24-hour period | | |
| Receptor | Criteria | Noise Level | Southern Array SW Corner | Northen Array NE Corner | North Array N Edge | Southern Array SW Corner | Northen Array NE Corner | North Array N Edge | Southern Array SW Corner | Northen Array NE Corner | North Array N Edge |
| **Mortality and Potentially Mortal Injury** | | | | | | | | | | | |
| Group 1 fish | $SPL_{peak}$ | 213 | 130m | 130m | 130m | 100m | 100m | 100m | 100m | 100m | 100m |
| | $SEL_{cum}$ (static) | 219 | 1.6km | 1.6km | 1.6km | 700m | 730m | 730m | 1.9km | 1.9km | 1.9km |
| | $SEL_{cum}$ (fleeing) | 219 | <100m | <100m | <100m | < 100 m | < 100 m | < 100 m | <100m | <100m | <100m |
| Group 2 fish | $SPL_{peak}$ | 207 | 340m | 340m | 340m | 270m | 270m | 270m | 260m | 260m | 270m |
| | $SEL_{cum}$ (static) | 210 | 5.4km | 5.4km | 5.5km | 2.7km | 2.7km | 2.7km | 6.2km | 6.1km | 6.2km |
| | $SEL_{cum}$ (fleeing) | 210 | <100m | <100m | <100m | < 100 m | < 100 m | < 100 m | <100m | <100m | <100m |
| Group 3 fish | $SPL_{peak}$ | 207 | 340m | 340m | 340m | 270m | 270m | 270m | 260m | 260m | 270m |
| | $SEL_{cum}$ (static) | 207 | 7.7km | 7.6km | 7.8km | 4.1km | 4.0km | 4.1km | 8.6km | 8.5km | 8.8km |

| | | | Monopile Impact Ranges | | | Pin Pile Impact Ranges | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Piling of a single monopile in a 24-hour period | | | Piling of a single pin pile in a 24-hour period | | | Sequential piling of up to four pin piles in a 24-hour period | | |
| | $SEL_{cum}$ (fleeing) | 207 | <100m | <100m | <100m | < 100 m | < 100 m | < 100 m | <100m | <100m | <100m |
| Eggs and larvae | $SPL_{peak}$ | 207 | 340m | 340m | 340m | 270m | 270m | 270m | 260m | 260m | 270m |
| | $SEL_{cum}$ (static) | 210 | 5.4km | 5.4km | 5.5km | 2.7km | 2.7km | 2.7km | 6.2km | 6.1km | 6.2km |
| **Recoverable injury** | | | | | | | | | | | |
| Group 1 fish | $SPL_{peak}$ | 213 | 130m | 130m | 130m | 100m | 100m | 100m | 100m | 100m | 100m |
| | $SEL_{cum}$ (static) | 216 | 2.5km | 2.4km | 2.5km | 1.1km | 1.1km | 1.1km | 2.9km | 2.8km | 2.9km |
| | $SEL_{cum}$ (fleeing) | 216 | <100m | <100m | <100m | < 100 m | < 100 m | < 100 m | <100m | <100m | <100m |
| Group 2 fish | $SPL_{peak}$ | 207 | 340m | 340m | 340m | 270m | 270m | 270m | 260m | 260m | 270m |
| | $SEL_{cum}$ (static) | 203 | 12km | 12km | 12km | 6.6km | 6.6km | 6.7km | 13km | 13km | 13km |
| | $SEL_{cum}$ (fleeing) | 203 | 1.6km | 1.5km | 1.6km | < 100 m | < 100 m | < 100 m | 230m | 200m | 250m |
| | $SPL_{peak}$ | 207 | 340m | 340m | 340m | 270m | 270m | 270m | 260m | 260m | 270m |

| | | | Monopile Impact Ranges | | | Pin Pile Impact Ranges | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Piling of a single monopile in a 24-hour period | | | Piling of a single pin pile in a 24-hour period | | | Sequential piling of up to four pin piles in a 24-hour period | | |
| Group 3 fish | $SEL_{cum}$ (static) | 203 | 12km | 12km | 12km | 6.6km | 6.6km | 6,7km | 13km | 13km | 13km |
| | $SEL_{cum}$ (fleeing) | 203 | 1.6km | 1.5km | 1.6km | < 100 m | < 100 m | < 100 m | 230m | 200m | 250m |
| **TTS** | | | | | | | | | | | |
| Group 1 fish | $SEL_{cum}$ (static) | 186 | 36km | 37km | 37km | 28km | 28km | 28km | 38km | 39km | 39km |
| | $SEL_{cum}$ (fleeing) | 186 | 22km | 23km | 23km | 17km | 18km | 18km | 19km | 19km | 19km |
| Group 2 fish | $SEL_{cum}$ (static) | 186 | 36km | 37km | 37km | 28km | 28km | 28km | 38km | 39km | 39km |
| | $SEL_{cum}$ (fleeing) | 186 | 22km | 23km | 23km | 17km | 18km | 18km | 19km | 19km | 19km |
| Group 3 fish | $SEL_{cum}$ (static) | 186 | 36km | 37km | 37km | 28km | 28km | 28km | 38km | 39km | 39km |
| | $SEL_{cum}$ (fleeing) | 186 | 22km | 23km | 23km | 17km | 18km | 18km | 19km | 19km | 19km |

*dB re 1 μPA Sound Exposure Level (SEL)/dB re 1 μPA2 Sound Exposure Level (SEL)

**Table 6.18 Noise modelling results for injury ranges for fleeing and stationary receptors for sequential piling at multiple locations**

| Receptor | Criteria | Noise Level* | Monopile Impact areas | Pin Pile Impact Areas |
|---|---|---|---|---|
| | | | Sequential piling of up to four monopiles in a 24-hour period, using a staggered approach | Sequential piling of up to eight pin piles in a 24-hour period, using a staggered approach |
| | | | Northern Array – N edge and Southern Array – SW corner | Northern Array – N edge and Southern Array – SW corner |
| **Mortality and Potential Mortal Injury** | | | | |
| **Group 1** | $SEL_{cum}$ (static) | 219 | 39 $km^2$ | 23 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 219 | < 0.1$km^2$ | < 0.1$km^2$ |
| **Group 2** | $SEL_{cum}$ (static) | 210 | 340$km^2$ | 220 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 210 | < 0.1$km^2$ | < 0.1$km^2$ |
| **Group 3** | $SEL_{cum}$ (static) | 207 | 630 $km^2$ | 430 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 207 | < 0.1 $km^2$ | < 0.1$km^2$ |
| **Eggs and Lavae** | $SEL_{cum}$ (static) | 210 | 340 $km^2$ | 220 $km^2$ |

| Receptor | Criteria | Noise Level* | Monopile Impact areas | Pin Pile Impact Areas |
|---|---|---|---|---|
| | | | Sequential piling of up to four monopiles in a 24-hour period, using a staggered approach | Sequential piling of up to eight pin piles in a 24-hour period, using a staggered approach |
| | | | Northern Array – N edge and Southern Array – SW corner | Northern Array – N edge and Southern Array – SW corner |
| **Recoverable Injury** | | | | |
| **Group 1** | $SEL_{cum}$ (static) | 216 | 85 $km^2$ | 51 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 216 | < 0.1 $km^2$ | < 0.1 $km^2$ |
| **Group 2** | $SEL_{cum}$ (static) | 203 | 1300 $km^2$ | 950 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 203 | 7.1 $km^2$ | 0.3 $km^2$ |
| **Group 3** | $SEL_{cum}$ (static) | 203 | 1300 $km^2$ | 950 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 203 | 7.1 $km^2$ | 0.3 $km^2$ |
| **TTS** | | | | |
| **Group 1** | $SEL_{cum}$ (static) | 186 | 5900 $km^2$ | 5200 $km^2$ |

| Receptor | Criteria | Noise Level* | Monopile Impact areas | Pin Pile Impact Areas |
|---|---|---|---|---|
| | | | Sequential piling of up to four monopiles in a 24-hour period, using a staggered approach | Sequential piling of up to eight pin piles in a 24-hour period, using a staggered approach |
| | | | Northern Array – N edge and Southern Array – SW corner | Northern Array – N edge and Southern Array – SW corner |
| | $SEL_{cum}$ (fleeing) | 186 | 1200 $km^2$ | 840 $km^2$ |
| **Group 2** | $SEL_{cum}$ (static) | 186 | 5900 $km^2$ | 5200 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 186 | 1200 $km^2$ | 840 $km^2$ |
| **Group 3** | $SEL_{cum}$ (static) | 186 | 5900 $km^2$ | 5200 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 186 | 1200 $km^2$ | 840 $km^2$ |

*dB re 1 µPA Sound Exposure Level (SEL)/dB re 1 µPA2 Sound Exposure Level (SEL)

**Table 6.19 Noise modelling results for injury ranges for fleeing and stationary receptors (concurrent piling at multiple locations)**

| Receptor | Criteria | Noise Level* | Monopile Impact Areas | Pin Pile Impact Areas |
|---|---|---|---|---|
| | | | Concurrent piling of up to four monopiles | Concurrent piling of up to eight pin piles |
| | | | Northern Array – N edge and Southern Array – SW corner | Northern Array – N edge and Southern Array – SW corner |
| **Mortality and Potentially Mortal Injury** | | | | |
| **Group 1** | $SEL_{cum}$ (static) | 219 | 39 km$^2$ | 23 km$^2$ |
| | $SEL_{cum}$ (fleeing) | 219 | - | - |
| **Group 2** | $SEL_{cum}$ (static) | 210 | 340 km$^2$ | 220 km$^2$ |
| | $SEL_{cum}$ (fleeing) | 210 | - | - |
| **Group 3** | $SEL_{cum}$ (static) | 207 | 630 km$^2$ | 430 km$^2$ |
| | $SEL_{cum}$ (fleeing) | 207 | - | - |
| **Eggs and Lavae** | $SEL_{cum}$ (static) | 210 | 340 km$^2$ | 220 km$^2$ |
| **Recoverable Injury** | | | | |

| Receptor | Criteria | Noise Level* | Monopile Impact Areas | Pin Pile Impact Areas |
|---|---|---|---|---|
| | | | Concurrent piling of up to four monopiles | Concurrent piling of up to eight pin piles |
| | | | Northern Array – N edge and Southern Array – SW corner | Northern Array – N edge and Southern Array – SW corner |
| Group 1 | $SEL_{cum}$ (static) | 216 | 85 $km^2$ | 51 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 216 | - | - |
| Group 2 | $SEL_{cum}$ (static) | 203 | 1300 $km^2$ | 950 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 203 | 260 $km^2$ | 170 $km^2$ |
| Group 3 | $SEL_{cum}$ (static) | 203 | 1,300 $km^2$ | 950 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 203 | 260 $km^2$ | 170 $km^2$ |
| **TTS** | | | | |
| Group 1 | $SEL_{cum}$ (static) | 186 | 5,900 $km^2$ | 5,200 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 186 | 2,400 $km^2$ | 1,900 $km^2$ |

| Receptor | Criteria | Noise Level* | Monopile Impact Areas | Pin Pile Impact Areas |
|---|---|---|---|---|
| | | | Concurrent piling of up to four monopiles | Concurrent piling of up to eight pin piles |
| | | | Northern Array – N edge and Southern Array – SW corner | Northern Array – N edge and Southern Array – SW corner |
| Group 2 | $SEL_{cum}$ (static) | 186 | 5,900 $km^2$ | 5,200 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 186 | 2,400 $km^2$ | 1,900 $km^2$ |
| Group 3 | $SEL_{cum}$ (static) | 186 | 5,900 $km^2$ | 5,200 $km^2$ |
| | $SEL_{cum}$ (fleeing) | 186 | 2,400$km^2$ | 1,900 $km^2$ |

*dB re 1 μPA Sound Exposure Level (SEL)/dB re 1 μPA2 Sound Exposure Level (SEL)

MORTALITY AND POTENTIAL MORTAL INJURY OF GROUP 1 VERS

SENSITIVITY

6.11.22 The following paragraphs provide the assessment of potential impacts on each VER within their associated hearing group for the spatial MDSs' and temporal MDS for underwater noise associated with foundation installation. Initial consideration is given to the sensitivity of each VER within the hearing group to underwater noise, before characterising the scale and magnitude of effect before providing the overall conclusion.

6.11.23 The potential for mortality or mortal injury is likely to only occur in extreme proximity to the pile, although the risk of this occurring will be reduced by use of soft start techniques at the start of the piling sequence. This means that fish in close proximity to piling operations will move outside of the impact range, before noise levels reach a level likely to cause irreversible injury (Robinson, Lepper and Ablitt (2007). Sensitivity

6.11.24 Group 1 VERs (mortality onset at >213 dB $SPL_{peak}$ or >219 dB $SEL_{cum}$) lack a swim bladder and are therefore considered less sensitive to underwater noise (than other species). The specific sensitivity rating assigned to each VER, and associated justification is provided in Table 6.20 below.

**Table 6.20: Group 1 VERs Sensitivity.**

| Group 1 VER | Sensitivity Justification |
|---|---|
| Sandeel | Sandeel lack a swim bladder and are therefore considered less sensitive to underwater noise. Sandeel spawning grounds are located within the study area and suitable spawning habitats are widely distributed across the wider Thames Estuary and southern North Sea therefore noise impacts are anticipated to be small in the context of the wider environment.<br><br>Sandeel are considered stationary receptors, due to their burrowing nature, substrate dependence, and demersal spawning behaviours, and therefore may have limited capacity to flee the area compared to other Group 1 receptors. Sandeel are thought to be affected by vibration through the seabed, particularly when buried in the seabed during hibernation. Sandeel are however, anticipated to recover from noise impacts shortly after noise disturbance, with normal behaviours resuming (Hassel *et al*., 2004). Taking this into account, sandeel are deemed to be of low vulnerability, **medium** recoverability and are of regional importance (Section 41 priority species). The sensitivity of the receptor to underwater noise impacts is therefore considered to be **low**. |
| Common sole, lemon sole, plaice, mackerel | Common sole, lemon sole, plaice and mackerel all have spawning grounds within the VE study area and across the southern North Sea (Coull *et al*., 1998). These species lack a swim bladder and are |

| Group 1 VER | Sensitivity Justification |
|---|---|
| | therefore considered less sensitive to underwater noise. These VERs are pelagic spawners and are therefore not limited to specific sedimentary areas for spawning, and consequently are considered likely to move away from injurious effects. Based on their mobile nature, these VERs are expected to recover quickly, return to normal behaviours, recolonizing areas shortly after disturbance. Therefore, the sensitivity of these VERs to noise impacts is considered to be **low**. |
| All other Group 1 VERs (dab, river and sea lamprey, elasmobranchs). | These species lack a swim bladder and are therefore considered less sensitive to underwater noise. In addition, these receptors are of mobile nature and are therefore able to flee from noise disturbance. Based on their low vulnerability to noise impacts, and their mobile nature, these receptors are expected to recover quickly, returning to normal behaviours, and recolonising areas shortly after disturbance. Taking this into account, the receptors are deemed to be of **low** vulnerability, **high** recoverability and are of regional to national importance. The sensitivity of these receptors to underwater noise impacts is therefore considered to be **low**. |

## MAGNITUDE OF IMPACT

6.11.25 Regarding the piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for mortality and potential mortal injury of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of up to four pin piles at a single location (hammer energy 3,000kJ) within a 24-hour period. An impact range of up to 1.9 km is predicted from this piling within the array areas for stationary Group 1 receptors. An impact range of up to 1.6 km is predicted from the piling of a single monopile foundation (hammer energy 7,000kJ) within a 24-hour period for stationary Group 1 receptors, and an impact range of up to 740 m is predicted from the piling of a single pin pile at a single location (hammer energy 3,000kJ) within a 24-hour period.

6.11.26 Regarding the impact ranges for fleeing receptors from the installation of foundations at single locations (Table 6.17), the predicted range of impact for mortality and potential mortal injury of fleeing Group 1 receptors is the same for all piling scenarios (the sequential piling of up to four pin piles, or the piling of a single monopile or pin pile in 24 hours. The range of impacts on fleeing Group 1 receptors are expected to be significantly less than the impact ranges predicted for stationary receptors, with mortality and potential mortal injury of fleeing receptors occurring <100 m from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.27 Regarding the sequential piling of foundations at multiple locations (Table 6.18) (the worst-case impact areas from this scenario will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area) the maximum predicted range of impact for mortality and potential mortal injury of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of up to two monopile foundations at both the north edge piling location (north array) and the southwest piling location (south array) (hammer energy 7,000 kJ) using a staggered approach (total four monopiles). An impact area of up to 39 $km^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 23 $km^2$ is predicted from the piling of up to four pin pile foundations at each location (hammer energy 3,000 kJ) using a staggered approach, within a 24-hour period for stationary Group 1 receptors (total eight pin piles).

6.11.28 Regarding the impact ranges for fleeing receptors from the sequential installation of foundations at multiple locations (Table 6.18), the predicted range of impact for mortality and potential mortal injury of fleeing Group 1 receptors is the same for both sequential piling scenarios. The maximum predicted area of impacts on fleeing Group 1 receptors are expected to be significantly less than the impact ranges predicted for stationary receptors, with mortality and potential mortal injury of fleeing receptors occurring <0.1 $km^2$ from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.29 There is also the potential for concurrent piling to be undertaken for pin piles or monopiles. The worst-case impact areas from concurrent piling will result from piling at both the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect of stationary Group 1 receptors results from the concurrent piling of two monopile foundations at both locations (four monopiles in total). An impact area of up to 39 $km^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 23 $km^2$ is predicted from the piling of up to four pin pile foundations (hammer energy 3,000 kJ) for stationary Group 1 receptors at both locations (eight pin piles in total). There is no potential for an in-combination area of effect of mortality and potential mortal injury from concurrent piling on fleeing receptors for either foundation type. Both the sequential piling of monopiles using a staggered approach, and the concurrent piling of monopiles represent the spatial MDS for mortality and potential mortal injury impacts.

6.11.30 With regards the temporal MDS, the maximum duration of piling results from the sequential piling of 340 pin piles, resulting in a total piling time of 1,360 hours (within 85 days), during a 12-month piling campaign. In the context of the annual sandeel spawning period (November to February (Ellis *et al*., 2012)) over one year, this equates to 47.6% respectively of the sandeel spawning period potentially impacted by piling noise. In the context of annual spawning periods for common sole, lemon sole, plaice and mackerel (March to May; November to January; December to March; and May to August respectively), this equates to 63%, 63%, 47.6% and 46.1% of the spawning periods respectively. However, for all receptors this assumes that all piling will occur within the spawning periods and therefore the actual temporal impact on the receptors will be significantly less.

6.11.31 Spawning grounds for all pelagic spawning and demersal spawning Group 1 receptors within the VE study area are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local scale (based on the modelling results). Given the broadscale nature of the Group 1 receptors spawning grounds, and the intermittent nature of the piling activities, the impact magnitude for mortality and potential mortal injury on spawning Group 1 receptors is therefore considered to be **low** for both the spatial and temporal MDS.

6.11.32 All other Group 1 receptors are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from underwater noise are of local scale (based on the modelling results). The magnitude of impact for mortality and potential mortal injury on these receptors is therefore considered to be of **negligible** magnitude.

### SIGNIFICANCE OF EFFECT

6.11.33 The impact of mortality and potential mortal injury of sandeel is considered to be of **low** magnitude, and the sensitivity of sandeel receptors affected is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.34 The impact of mortality and potential mortal injury on spawning Group 1 receptors is considered to be of **low** magnitude, and the sensitivity of Group 1 receptors affected is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.35 The impact of mortality and potential mortal injury on all other Group 1 receptors is considered to be of **negligible** magnitude, and the sensitivity of Group 1 receptors affected is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## MORTALITY AND POTENTIAL MORTAL INJURY OF GROUP 2 VERS

### SENSITIVITY

6.11.36 Group 2 receptors (mortality onset at >207 dB $SPL_{peak}$ or >210 dB $SEL_{cum}$) have a swim bladder and are therefore considered more sensitive to underwater noise than Group 1 species (i.e., the species have an internal air sac which can be affected by sound pressure effects), however, the swim bladder is not involved in hearing (e.g. not linked to the inner ear) and as such they are less sensitive than Group 3 receptors.

6.11.37 Group 2 species identified as of relevance to VE are Atlantic salmon and sea trout. As Group 2 receptors, they are considered to be primarily sensitive to particle motion and so are likely to mainly sense underwater noise through movement of the water particles. The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.21 below.

**Table 6.21: Group 2 VERs Sensitivity.**

| Group 2 VER | Sensitivity Justification |
|---|---|
| Atlantic salmon, sea trout | These species have a swim bladder and are therefore considered more sensitive to underwater noise than Group 1 species. Atlantic salmon are migratory species; in late spring to early summer, adult Atlantic salmon return to rivers to spawn, whilst juvenile salmon migrate out to sea to feed. In addition, sea trout are also migratory, with most sea trout migrating into rivers in June, and back out to sea in October. Atlantic salmon and sea trout are therefore likely to be transient receptors within the site. They are therefore considered to be mobile receptors, and able to flee from noise impacts.<br><br>Based on their low vulnerability to noise impacts, and their mobile nature, these receptors are expected to recover quickly, returning to normal behaviours, and recolonising areas shortly after disturbance. Sea trout and Atlantic salmon are therefore considered to be of **low** vulnerability, **medium** recovery, and regional (sea trout) to national (Atlantic salmon) importance. The sensitivity of these receptors to underwater noise impacts is therefore considered to be **low**. |

## MAGNITUDE OF IMPACTS

6.11.38 Both salmon and sea trout are considered fleeing receptors within this assessment, as they are both migratory species and are therefore likely to be transient receptors within the site. Therefore, the magnitude of impact on static Group 2 receptors for mortality and potential mortal injury is not considered.

6.11.39 Regarding piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for mortality and potential mortal injury of fleeing Group 2 receptors is the same for all piling scenarios (the piling of a single monopile or pin pile in a 24-hour period, or the sequential piling of up to four pin piles in a 24 hour period. Mortality and potential mortal injury of fleeing Group 2 receptors is predicted to occur <100 m from the source, within the immediate vicinity of the piling activity.

6.11.40 Regarding the impact ranges for fleeing receptors from the sequential installation of foundations at multiple locations using a staggered approach, the predicted range of impact for mortality and potential mortal injury of fleeing Group 2 receptors is the same for both piling scenarios (the sequential piling of up to four pin piles at each locations (total of eight pin piles) (hammer energy 3,000), or the sequential piling of two monopiles at each location (total four monopiles) (hammer energy 7,000 kJ)). The maximum predicted area of impacts on fleeing Group 2 receptors are expected to occur <0.1km$^2$ from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.41 There is no potential for an in-combination area of effect from concurrent piling of either foundation type on fleeing receptors.

6.11.42 Regarding the temporal MDS, Atlantic salmon and sea trout have the potential to be within range of injurious effects from piling noise during migration, however these VERs are anticipated to be transient across the site, not remaining within the study area for any significant duration (unlike spawning receptors), therefore any temporal impacts on these receptors are anticipated to be minimal, and the temporal MDS has not been calculated. Taking into account the limited impact range anticipated on fleeing Group 2 receptors, and the transient nature of Atlantic salmon and sea trout across the site, it is anticipated that there will be a barely discernible change from baseline conditions, therefore the magnitude of impact to Group 2 receptors from the spatial MDS is considered to be low.

#### SIGNIFICANCE OF EFFECTS

6.11.43 The impact of mortality and potential mortal injury on Group 2 receptors, is considered to be of **low** magnitude, and the maximum sensitivity of receptors affected is considered to be **low** for sea trout and Atlantic salmon. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### MORTALITY AND POTENTIAL MORTAL INJURY OF GROUP 3 VERS

#### SENSITIVITY

6.11.44 Group 3 receptors (mortality onset at >207 dB $SPL_{peak}$ or >207 dB $SEL_{cum}$) have a swim bladder which is linked to the inner ear and so is directly involved in hearing. These species are considered to be the most sensitive to underwater noise, with direct detection of sound pressure, rather than just particle motion. The sensitivity rating assigned to each VER, and associated justification are provided in Table 6.22 below.

**Table 6.22: Group 3 VERs Sensitivity.**

| Group 3 VER | Sensitivity Justification |
|---|---|
| Spawning herring | Herring possess a swim bladder that is involved in hearing, and therefore are known to be sensitive to underwater noise. The southwestern corner of the VE study area, as indicated by Coull *et al*., (1998), has a slight overlap with the Blackwater herring stock spawning ground, and the eastern extent of the VE study area overlaps an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998).<br><br>Herring are demersal spawners and are therefore considered stationary receptors in the assessment during the spawning season (November to January), increasing their theoretical exposure to underwater noise from the construction phase of the development. Taking this into account, herring are considered to be of high vulnerability, with **medium** recoverability and of regional importance (Section 41 priority species), therefore the |

| Group 3 VER | Sensitivity Justification |
|---|---|
| | sensitivity of spawning herring to noise impacts is considered to be **medium**. |
| Seahorse | Seahorse possess a swim bladder that is involved in hearing, and therefore are known to be sensitive to underwater noise. Seahorses can be found in a variety of habitats, including sand and soft sediment, seagrass meadows, rock and algae and artificial habitats (such as marinas) (Woodall *et al*., 2018), and short snouted seahorse have been recorded within the wider Thames estuary. Seahorses have low swimming speeds, with very inefficient fins for conventional swimming (Ashley-Ross, 2002) and therefore may have limited capacity to flee the area. However, seahorses are not expected in significant numbers in the study, as there are no records or data that suggest that the array areas or offshore ECC are an area of particular importance for seahorse. Taking this into account, seahorse are considered to be of **high** vulnerability, with **medium** recoverability and of national importance (Priority Species under the UK Post-2010 Biodiversity Framework and protected under the Wildlife and Countryside Act 1981), therefore the sensitivity of seahorse to noise impacts is considered to be **high**. |
| European sea bass | European sea bass possess a swim bladder that is involved in hearing, and therefore are known to be sensitive to underwater noise. Sea bass nursery areas are located in the wider Thames estuary, outside of the fish and shellfish study area. Sea bass are pelagic spawners, and do not display substrate dependency during spawning behaviours, they are therefore expected to flee the area with the onset of 'soft start' piling. Taking this into account, European seabass are considered to be of **low** sensitivity to noise impacts. |
| Cod, whiting, sprat and horse mackerel. | Cod, whiting and horse mackerel all have spawning grounds within the VE study area and across the southern North Sea (Coull *et al*., 1998). These VERs are pelagic spawners and are therefore not limited to specific sedimentary areas for spawning, and consequently are considered likely to move away from injurious effects. Based on their mobile nature, these VERs are expected to recover quickly, return to normal behaviours, recolonizing areas shortly after disturbance. Therefore, the sensitivity of these VERs to noise impacts is considered to be **low**. |
| All other Group 3 receptors (, European eel, allis and twaite shad, smelt, tub gurnard, red gurnard, sea bass). | These VERs are key components of the fish assemblages within the VE study area or are of commercial or conservation importance to the region. Based on their mobile nature, these receptors are expected to recover quickly, returning to normal behaviours, recolonizing areas shortly after disturbance, |

| Group 3 VER | Sensitivity Justification |
|---|---|
| | therefore, the sensitivity of these VERs to noise impacts is considered to be **low**. |

MAGNITUDE OF IMPACT

6.11.45 Regarding the piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for mortality and potential mortal injury of stationary Group 3 receptors (e.g., spawning herring and seahorse) occurs from the sequential installation of up to four pin piles at a single location (hammer energy 3,000kJ) within a 24-hour period. An impact range of up to 8.8km is predicted from this piling within the array areas for stationary Group 3 receptors. An impact range of up to 7.8km is predicted from the piling of a single monopile foundation within a 24-hour period for stationary Group 3 receptors, and an impact range of up to 4.1km is predicted from the piling of a single pin pile foundation.

6.11.46 Regarding the impact ranges for fleeing receptors from the installation of foundations at single locations (Table 6.17), the predicted range of impact for mortality and potential mortal injury of fleeing Group 3 receptors is the same for each piling scenario (the sequential piling of up to four pin piles, or the piling of a single monopile or pin pile in 24 hours). The maximum predicted range of impacts on fleeing Group 1 receptors are expected to be significantly less than the impact ranges predicted for stationary receptors, with mortality and potential mortal injury of fleeing receptors occurring <100 m from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.47 Regarding the sequential piling of foundations at multiple locations (Table 6.18) (the worst-case impact areas from this scenario will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area) the maximum predicted area of impact for mortality and potential mortal injury of stationary Group 3 receptors occurs from the sequential installation of up to two monopile foundations using a staggered approach, at both the north edge piling location (north array) and the southwest piling location (south array) (hammer energy 7,000kJ) (total four monopile foundations). An impact area of up to 630km$^2$ is predicted from this piling scenario within the array areas for stationary Group 3 receptors. An impact area of up to 430km$^2$ is predicted from the sequential piling of up to four pin pile foundations at both locations using a staggered approach (hammer energy 3,000kJ) (total eight pin piles).

6.11.48 Regarding the impact ranges of mortality and potential mortal injury for fleeing receptors from the sequential installation of foundations at multiple locations using a staggered approach (Table 6.18), the predicted range of impact for mortality and potential mortal injury of fleeing Group 3 receptors is the same for both piling scenarios (the sequential piling of up to four pin piles (hammer energy 3,000), or the sequential piling of two monopiles (hammer energy 7,000 kJ)). The maximum predicted area of impacts on fleeing Group 3 receptors are expected to be significantly less than the impact ranges predicted for stationary receptors, with mortality and potential mortal injury of fleeing receptors occurring <0.1km$^2$ from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.49 There is also the potential for concurrent piling to be undertaken for pin piles or monopiles. The worst-case impact areas from concurrent piling will result from piling at both the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect of mortality and potential mortal injury on stationary Group 3 receptors results from the concurrent piling of two monopile foundations at both locations. An impact area of up to 630km$^2$ is predicted from this piling scenario within the array areas for stationary Group 3 receptors. An impact area of up to 430km$^2$ is predicted from the piling of up to four pin pile foundations at both locations (hammer energy 3,000kJ) for stationary Group 3 receptors.

6.11.50 There is no potential for an in-combination area of effect of mortality and potential mortal injury from concurrent piling on fleeing receptors for either foundation type.

6.11.51 Both the sequential piling of monopiles using a staggered approach, and the concurrent piling of monopiles represent the spatial MDS for mortality and potential mortal injury impacts.

6.11.52 The noise contours are shown in relation to herring spawning grounds and larvae abundances (Coull *et al*., 1998 and IHLS data (2007 – 2021)) in Figure 6.12 to Figure 6.23 for each piling scenario. The figures indicate the potential for mortality and potential mortal injury of spawning herring. A slight overlap of the mortality and potential mortal injury noise contours from all piling scenarios with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998) can be observed in Figure 6.12 to Figure 6.15, although as shown by annual IHLS data (ICES, 2007-2022 (Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data)), the main spawning area utilised by the Downs herring stock is located in the Eastern Channel (as informed by relative larvae abundances), and spawning intensity on the Downs spawning grounds that overlap with VE (as defined by Coull et al., 1998) is much less intense; long time series data confirm this has been the case since the 1970's (see -Dickey-Collas et al., 2009 and Pawson, 1995). In addition, as shown by PSA data across the site (Fugro, 2022a,b; BGS, 2015) suitable herring spawning substrates are located across the site, and the Thames Estuary and English Channel. Therefore, taking the above into account, the potential for mortality and potential mortal injury from piling is unlikely to have a population level effect of the Downs herring stock within the Thames Estuary and English Channel. There is no overlap of the mortality and potential mortal injury noise contour with the Blackwater herring stock spawning ground, and therefore there will be no impact from piling on the spawning of the Blackwater herring stock.

6.11.53 With regards the temporal MDS, the maximum duration of piling results from the piling of 340 pin piles, resulting in a total piling time of 1,360 hours, within a 12-

month piling campaign for both array areas. In the context of the annual herring spawning period for the Downs and Blackwater herring spawning stock (November to January, Coull *et al*., (1998)) (across the Thames Estuary and English Channel) over one year this equates to 61.6% respectively of the herring spawning period potentially impacted by piling noise. In the context of annual spawning periods for cod, whiting, sprat and horse mackerel (January to April, February to June, May to August, and March to August respectively) this equates to 47.6%, 38%, 46.4% and 30.9% respectively. However, for all receptors this assumes that all piling will occur within the spawning periods and therefore the actual temporal impact on the receptors will be significantly less.

6.11.54 Considering the slight overlap of the mortality and potential mortal injury noise contours with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998) in relation to the overall extent of the spawning ground, and the of areas of low-density herring larvae present within the noise contour extents (Figure 6.12 to Figure 6.15) the magnitude of impact from mortality and potential mortal injury on spawning Downs stock herring (across the Thames Estuary and English Channel) from piling activities is considered to be **low**.

6.11.55 As there is no overlap of the mortality and potential mortal injury noise contours of the Blackwater herring spawning ground (Figure 6.12 to Figure 6.15), the magnitude of impact on the Blackwater herring stock from piling activities is considered to be **negligible**.

6.11.56 Whilst there is the potential for seahorse to be present, VE does not lie within an area of specific importance for the species. Nevertheless, there is potential for seahorse to occur in deeper waters within the region generally, relating to overwintering migration, which could feasibly result in the seahorse species being present in the general area of VE. Whilst interaction with individual seahorses cannot be ruled out, the overall risk of interaction is considered to be low, and spatially discrete. This is due to the low number of records of the species across the region, and consequently the very low density following the species' broad migration to wide areas of 'deeper water’, it is considered that the risk of one or more of these individuals being located within the impact ranges from piling at the time of active piling is very small (Pierri *et al.,* 2022). Therefore, taking into consideration, the limited temporal and spatial impact from the piling locations of VE and the numbers of seahorse identified in the region. The magnitude of the impact of mortality and potential mortal injury that construction activities relating to the VE will have on seahorse is considered **negligible**.

6.11.57 Considering the spatially limited extent of the noise contours, there is no overlap with sea bass nursery areas, and therefore the magnitude of impact from mortality and potential mortal injury of sea bass within their nursery grounds from piling activities is considered to be **negligible**.

6.11.58 Spawning grounds for cod, whiting, sprat and horse mackerel are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local scale (based on the modelling results). The magnitude of impact from mortality and potential mortal injury from piling activities on these receptors is therefore considered to be **low**.

6.11.59 All other Group 3 receptors are present in abundance within the region, and therefore any impacts from underwater noise are expected to be of local scale. Given the broadscale distribution of these receptors, and the intermittent nature of the piling activities, the maximum magnitude of impact from mortality and potential mortal injury is expected to be **negligible**.

### SIGNIFICANCE OF EFFECT

6.11.60 The impact of mortality and potential mortal injury on the Downs herring stock, is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.61 The impact of mortality and potential mortal injury on the Blackwater herring stock is considered to be of **negligible** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.62 The impact of mortality and potential mortal injury on seahorse, is considered to be of **negligible** magnitude, and the sensitivity of the receptor is considered to be **high**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.63 The impact of mortality and potential mortal injury on seabass within nursery areas, is considered to be of **negligible** magnitude, and the sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.64 The impact of mortality and potential mortal injury on spawning Group 3 receptors, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.65 The impact of mortality and potential mortal injury on all other Group 3 receptors is considered to be of **negligible** magnitude, and the sensitivity of Group 1 receptors affected is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## MORTALITY AND POTENTIAL MORTAL INJURY OF EGGS AND LARVAE

### SENSITIVITY

6.11.66 Plaice, sole, cod, horse mackerel, sandeel, herring, mackerel, sprat, whiting and lemon sole all have spawning grounds within the vicinity of VE (Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report). Eggs and larvae are considered organisms of concern by Popper *et al*., (2014), due to their vulnerability, reduced mobility and small size. Taking this into consideration and given the broadscale nature of the spawning grounds, the sensitivity of eggs and larvae to mortality and potential mortal injury from underwater noise is considered to be **medium**. Thresholds of effects for eggs and larvae have been defined separately within the Popper *et al*., (2014) guidance, with damage expected to occur at 210 dB $SEL_{cum}$ or >207 dB $SPL_{peak}$.

### MAGNITUDE OF IMPACT

6.11.67 Regarding the piling of foundations at single locations (Table 6.17), the maximum predicted range of impact for the mortality and potential mortal injury of eggs and larvae occurs from the sequential installation of up to four pin piles at a single location (hammer energy 3,000kJ) within a 24-hour period. An impact range of up to 6.2 km is predicted from this piling scenario within the array areas for eggs and larvae. Impact ranges of up to 5.5km and 2.7km are predicted from the piling of a single monopile and pin pile respectively within a 24-hour period for eggs and larvae.

6.11.68 Regarding the sequential piling of foundations at multiple locations using a staggered approach (Table 6.18) (the worst-case impact areas from this scenario will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area) the maximum predicted range of impact for mortality and potential mortal injury of eggs and larvae occurs from the sequential installation of up to two monopile foundations at both the north edge piling location (north array) and the southwest piling location (south array) (hammer energy 7,000kJ) (total four monopiles). An impact area of up to 340km$^2$ is predicted from this piling scenario within the array areas for eggs and larvae. An impact area of up to 220km$^2$ is predicted for mortality and potential mortal injury from the piling of up to four pin pile foundations at each location (hammer energy 3,000kJ) (total eight pin piles) for eggs and larvae.

6.11.69 There is also the potential for concurrent piling to be undertaken (Table 6.19) for pin piles or monopiles. The worst-case impact areas of mortality and potential mortal injury from concurrent piling will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect of eggs and larvae results from the concurrent piling of two monopile foundations at both locations. An impact area of up to 340km$^2$ is predicted from this piling scenario within the array areas for eggs and larvae. An impact area of up to 220km$^2$ is predicted from the piling of up to four pin pile foundations at each location (hammer energy 3,000kJ) for eggs and larvae.

6.11.70 Considering the discrete overlap of the mortality and potential mortal injury noise contours with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), in relation to the overall extent of the spawning ground (across the Thames Estuary and English Channel), and the location of high densities of herring larvae outside of the noise contours, the magnitude of impact on herring eggs and larvae from piling activities is considered to be **low**.

6.11.71 As there is no overlap of the mortality and potential mortal injury noise contours of the Blackwater herring spawning ground, the magnitude of impact from mortality and potential mortal injury on the Blackwater herring stock from piling activities is considered to be **negligible**.

6.11.72 Considering the broad distribution of all other receptors spawning grounds across the wider Thames estuary and southern North Sea, the magnitude of impact from mortality and potential mortal injury on eggs and larvae from piling activities is considered to be **low**.

## SIGNIFICANCE OF EFFECT

6.11.73 The impact of mortality and potential mortal injury on Downs herring stock eggs and larvae, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.74 The impact of mortality and potential mortal injury on Blackwater herring stock eggs and larvae, is considered to be of **negligible** magnitude, and the sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.75 The impact of mortality and potential mortal injury on all other receptor eggs and larvae, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## MORTALITY AND POTENTIAL MORTAL INJURY OF SHELLFISH

6.11.76 On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure (e.g., Popper and Hawkins, 2018). As there are currently no criteria for assessing particle motion, it is not possible to undertake a threshold-based assessment of the potential for injury to shellfish in the same way as can be done for fish. As such, a qualitative assessment of the potential for mortality or mortal injury has been made based on peer-reviewed literature. This is a standard approach that has been applied to a number of OWF applications (Hornsea Four OWF (Ørsted, 2021), Awel y Mor OWF (RWE, 2022), Sheringham Shoal and Dudgeon OWF Extension Projects (Equinor, 2022), Norfolk Boreas OWF (Vattenfall, 2019)).

6.11.77 Pile driving is recognised as a source particle motion, generating high levels of particle motion in the nearfield (Hazelwood and Macey, 2016a) which could potentially result in injury or mortality to sensitive shellfish receptors. Impacts from particle motion are also likely to occur local to the source, with studies having demonstrated the rapid attenuation of particle motion with distance (Mueller-Blenkle *et al*., 2010). Studies on lobsters have shown no mortality effect on the species

(>220 dB) (Payne *et al*., 2007). Similarly, studies of molluscs (e.g., blue mussels *Mytilus edulis* and periwinkles *Littorina* spp.) exposed to a single airgun at a distance of 0.5 m have shown no effects after exposure (Kosheleva, 1992). Taking this into consideration, shellfish VERs within the study area are deemed to be of local to regional importance, **medium** vulnerability, and **high** recoverability. The sensitivity of these receptors is therefore considered to be low.

6.11.78 Due to the commercial value and importance of cockles and whelk to the region, due consideration is given to the potential for impacts on these species from noise impacts during construction. There is evidence to suggest that marine invertebrates respond to noise in a similar way to predators. The common cockle for example responded to sound by retracting its feeding tubes and burying deeper into the sand. When this behaviour occurs cockles are unable to feed, which may put their survival and ability to reproduce at risk (Kastelein, 2008). However, considering the intermittent nature of the piling activities, no population level effects are anticipated. Furthermore, sensitivity assessments undertaken by the Marine Life Information Network (MarLIN) on common cockle and dog whelk (used as proxy for common whelk in the absence of a sensitivity assessment for common whelk) concluded that these species may be sensitive to local vibrations within their vicinity, likely caused by predators, but are unlikely to be sensitive to underwater noise such as that caused by piling (Tyler-Walters, 2007a; Tyler-Walters, 2007b). The sensitivity of cockles and whelk is therefore considered to be low.

6.11.79 Taking the widespread presence of these receptors across UK waters into account, and the proportionately small numbers of individuals that would be affected (relative to the wider population) the magnitude of effect on shellfish receptors is assessed as low.

6.11.80 Taking into account the broad distribution of these receptors across the study area, the available literature suggesting a **low** risk of mortality or significant injury, and the relatively short-term nature of the impact, it is considered unlikely that there will be any more than a highly localised effect, with rapid recovery of the remaining stock avoiding a population level effect.

6.11.81 The impact of mortality and potential mortal injury on shellfish, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## RECOVERABLE INJURY OF GROUP 1 VERS

6.11.82 Recoverable injury is a survivable injury with full recovery occurring after exposure, although decreased fitness during this recovery period may result in increased susceptibility to predation or disease (Popper *et al*., 2014). The impact ranges for recoverable injury and mortality/potential mortal injury are more or less the same due to the thresholds used, the potential for mortality or mortal injury is likely to only occur in extreme proximity to the pile, although the risk of this occurring will be reduced by use of soft start techniques at the start of the piling sequence. This means that fish in close proximity to piling operations will move outside of the impact range, before noise levels reach a level likely to cause irreversible injury.

### SENSITIVITY OF VERS

6.11.83 As noted previously in Table 6.20, sandeel are a Group 1 receptor (recoverable injury onset at 216 dB $SEL_{cum}$), considered to be of **low** sensitivity to underwater noise, with spawning grounds located across the Southern North Sea. All other Group 1 receptors have **low** sensitivity to recoverable injury from piling activities.

### MAGINITUDE OF IMPACT

6.11.84 Regarding the piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for recoverable injury of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of up to four pin piles at a single location (hammer energy 3,000kJ) within a 24-hour period. An impact range of up to 2.9 km is predicted from this piling within the array areas for stationary Group 1 receptors. An impact range of up to 2.5 km is predicted from the piling of a single monopile foundation (hammer energy 7,000kJ) within a 24-hour period for stationary Group 1 receptors. An impact range of up to 1.1km is predicted from the piling of a single pin pile foundation (hammer energy 3,000kJ) within a 24 hour period.

6.11.85 Regarding the impact ranges for fleeing receptors from the installation of foundations at single locations (Table 6.17), the predicted range of impact for recoverable injury of fleeing Group 1 receptors is the same for each piling scenario (the sequential piling of up to four pin piles, or the piling of a single monopile or pin pile in 24 hours. The maximum predicted range of impacts on fleeing Group 1 receptors are expected to be significantly less than the impact ranges predicted for stationary receptors, with recoverable injury of fleeing receptors occurring <100 m from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.86 Regarding the sequential piling of foundations at multiple locations using a staggered approach (Table 6.18) the maximum predicted range of impact for recoverable injury of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of up to two monopile foundations at the north edge piling location (north array) and the southwest piling location (south array) (total four monopiles) (hammer energy 7,000kJ). An impact area of up to 85 $km^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 51 $km^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for stationary Group 1 receptors.

6.11.87 Regarding the impact ranges for fleeing receptors from the sequential installation of foundations at multiple locations using a staggered approach (Table 6.18), the predicted range of impact for recoverable injury of fleeing Group 1 receptors is the same for both piling scenarios (the sequential piling of up to four pin piles at each location (hammer energy 3,000), or the sequential piling of two monopiles at each location (hammer energy 7,000 kJ)). The maximum predicted area of impacts on fleeing Group 1 receptors are expected to be significantly less than the impact ranges predicted for stationary receptors, with recoverable injury of fleeing receptors occurring <0.1km$^2$ from the source, within the immediate vicinity of the piling activity for either foundation type.

6.11.88 There is the potential for concurrent piling to be undertaken for pin piles or monopiles (Table 6.19). The worst-case impact areas from concurrent piling will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect of stationary Group 1 receptors results from the concurrent piling of two monopile foundations at both locations. An impact area of up to 85km$^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 51km$^2$ is predicted from the concurrent piling of up to four pin pile foundations at each location (hammer energy 3,000kJ) for stationary Group 1 receptors. There is no potential for an in-combination area of effect from concurrent piling on fleeing receptors for either foundation type. Both the sequential piling and concurrent piling scenarios for monopile foundations at multiple locations represent the spatial MDS for stationary receptors for recoverable injury impacts.

6.11.89 Sandeel are known to be present around a substantial proportion of the UK coast and have suitable habitats and spawning grounds that are correspondingly broad. Considering this broad distribution of suitable spawning habitats across the Southern North Sea, the more distant areas and the localised range of any injurious impacts, there are not considered to be any population level effects on the species from recoverable injury.

6.11.90 Spawning grounds for all other Group 1 receptors within the VE study area are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from recoverable injury are considered to be of local scale (based on the modelling results).

6.11.91 With regards the temporal MDS, the maximum duration of piling results from the piling of 340 pin piles, resulting in a total piling time of 1,360 hours, within a 12-month piling campaign. In the context of the annual sandeel spawning period (November to February (Ellis *et al*., 2012)) over one year, this equates to 47.6% respectively of the sandeel spawning period potentially impacted by piling noise. In the context of annual spawning periods for common sole, lemon sole, plaice and mackerel (March to May; November to January; December to March; and May to August respectively), this equates to 63%, 63%, 47.6% and 46.1% of the spawning periods respectively. However, for all receptors this assumes that all piling will occur within the spawning periods and therefore the actual temporal impact on the receptors will be significantly less.

6.11.92 Given the broadscale nature of sandeel spawning grounds, and the intermittent nature of the piling activities, the impact magnitude for recoverable injury on sandeel is considered to be **low** for both the spatial and temporal MDS.

6.11.93 Given the broadscale nature of the Group 1 receptors spawning grounds, and the intermittent nature of the piling activities, the impact magnitude for recoverable injury on spawning Group 1 receptors is considered to be **low** for both the spatial and temporal MDS.

6.11.94 All other Group 1 receptors are present in abundance within the region, and therefore any impacts from underwater noise are expected to be of local scale. Given the broadscale distribution of these receptors, and the intermittent nature of the piling activities, the maximum magnitude of impact from recoverable injury is expected to be **negligible**.

### SIGNIFICANCE OF EFFECT

6.11.95 The impact of recoverable injury on sandeel, is considered to be of **low** magnitude, and the sensitivity of sandeel is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.96 The impact of recoverable injury of spawning Group 1 receptors, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.97 The impact of recoverable injury on all other Group 1 receptors, is considered to be of **negligible** magnitude, and the sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## RECOVERABLE INJURY OF GROUP 2 VERS

### SENSITIVITY OF VERS

6.11.98 As detailed in Table 6.21, Group 2 receptors (recoverable injury onset at >207 dB $SPL_{peak}$ or >203 dB $SEL_{cum}$) are considered to be of **low** sensitivity to underwater noise.

### MAGINITUDE OF IMPACT

6.11.99 Regarding the piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for recoverable injury of fleeing Group 2 receptors occurs from the installation of one monopile foundation at a single location (hammer energy 7,000kJ) within a 24-hour period. An impact range of up to 1.6 km is predicted from this piling within the array areas for fleeing Group 2 receptors. An impact range of <100m is predicted from the piling of a single pin pile within a 24-hour period, and a range up to 250m is predicted from the sequential piling of up to four pin piles (hammer energy 3,000kJ) within a 24 hour period for fleeing Group 2 receptors.

6.11.100 Regarding the sequential piling of foundations at multiple locations using a staggered approach (Table 6.19) the maximum predicted range of impact for recoverable injury of fleeing Group 2 receptors occurs from the sequential installation of up to two monopile foundations at both the north edge piling location (north array) and the southwest piling location (south array) (hammer energy 7,000kJ) (total frou monopile foundations). An impact area of up to 7.1km$^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 0.3km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for fleeing Group 2 receptors.

6.11.101 There is the potential for concurrent piling to be undertaken for pin piles or monopiles (Table 6.19). The worst-case impact areas from concurrent piling will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect for the recoverable injury of fleeing Group 2 receptors results from the concurrent piling of two monopile foundations at both locations (total four monopiles). An impact area of up to 260km$^2$ is predicted from this piling scenario within the array areas for fleeing Group 2 receptors. This piling scenario represents the spatial MDS for the recoverable injury of fleeing Group 2 receptors. An impact area of up to 170km$^2$ is predicted from the piling of up to four pin pile foundations (total eight pin piles) for fleeing Group 2 receptors.

6.11.102 Regarding the temporal MDS, Atlantic salmon and sea trout have the potential to be within range of injurious effects from piling noise, however these VERs are anticipated to be transient across the site, and therefore any temporal impacts on these receptors are anticipated to be minimal. Taking into account the limited impact range anticipated on fleeing Group 2 receptors, and the transient nature of Atlantic salmon and sea trout across the site, it is anticipated that there will be a barely discernible change from baseline conditions, the magnitude of impact to Group 2 receptors from the spatial MDS for recoverable injury is considered to be low.

#### SIGNIFICANCE OF EFFECTS

6.11.103 The impact of recoverable injury on Group 2 receptors, is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### RECOVERABLE INJURY OF GROUP 3 VERS

#### SENSITIVITY OF VERS

6.11.104 As noted above in Table 6.22, spawning herring (Group 3 receptor, recoverable injury onset at 203 dB $SEL_{cum}$) are considered to be of **medium** sensitivity. Seahorse (Group 3 receptor, recoverable injury onset at 203 dB $SEL_{cum}$) however are of **high** sensitivity to underwater noise. All other Group 3 receptors are of **low** sensitivity to underwater noise impacts from piling activities.

#### MAGNITUDE OF EFFECTS

6.11.105 Regarding the piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for recoverable injury of stationary Group 3 receptors (e.g., spawning herring and seahorse) occurs from the sequential installation of up to four pin piles at a single location (hammer energy 3,000kJ) within a 24 hour period. A maximum impact range of up to 13km is predicted from this piling within the array areas for stationary Group 3 receptors. An impact range of up to 12km is predicted from the piling of a single monopile foundation (hammer energy 7,000kJ) within a 24 hour period for stationary Group 3 receptors, and an impact range of up to 6.7km is predicted for the piling of a single pin pile in a 24-hour period.

6.11.106 Regarding the impact ranges of recoverable injury for fleeing receptors from the installation of foundations at single locations (Table 6.17), the maximum predicted range of impact for recoverable injury of fleeing Group 3 receptors results from the piling of one monopile at a single location (hammer energy 7,000kJ) in a 24 hour period. An impact range of up to 1.6km is predicted from this piling scenario within the array areas for fleeing Group 3 receptors. An impact range of <100m is predicted for the piling of a single pin pile in a 24-hour period, and a recoverable injury impact range of up to 1.6km is predicted from the sequential piling of up to four pin pile foundations for fleeing Group 3 receptors.

6.11.107 Regarding the sequential piling of foundations at multiple locations using a staggered approach (Table 6.18) the maximum predicted range of impact for recoverable injury of stationary Group 3 receptors (occurs from the sequential installation of up to two monopile foundations at both the north edge piling location (north array) and the southwest piling location (south array) (total four monopiles) (hammer energy 7,000kJ). An impact area of up to 1,300km$^2$ is predicted from this piling scenario within the array areas for stationary Group 3 receptors. An impact area of up to 950km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for stationary Group 3 receptors.

6.11.108 Regarding the impact ranges of recoverable injury for fleeing receptors from the sequential installation of foundations at multiple locations (Table 6.18), the maximum range of impact for recoverable injury of fleeing Group 3 receptors results from the sequential piling of two monopile foundations at both the north edge piling location (north array) and the southwest piling location (south array) (total four monopiles) (hammer energy 7,000 kJ). An impact area of up to 7.1 km$^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 0.3km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for fleeing Group 3 receptors.

6.11.109 There is also the potential for concurrent piling to be undertaken for pin piles or monopiles (Table 6.19). The worst-case recoverable injury impact areas from concurrent piling will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect of stationary Group 3 receptors results from the concurrent piling of two monopile foundations at both locations (total four monopiles). An impact area of up to 1300 km$^2$ is predicted from this piling scenario within the array areas for stationary Group 3 receptors. A recoverable injury impact area of up to 950km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for stationary Group 3 receptors. The spatial MDS for the recoverable injury of stationary receptors results from both the sequential and concurrent piling of monopile foundations.

6.11.110 An impact area of up to 260 km$^2$ is predicted from the concurrent piling of two monopile foundations at each location for fleeing Group 3 receptors. This piling scenario represents the spatial MDS for recoverable injury of fleeing Group 3 receptors. An impact area of up to 170 km$^2$ is predicted from the concurrent piling of up to four pin pile foundations at each location (hammer energy 3,000kJ) for fleeing Group 3 receptors.

6.11.111 The noise contours shown in relation to herring spawning grounds and larvae abundances (Coull *et al.*, 1998 and IHLS data (2007 – 2020) in Figure 6.12 to Figure 6.15, indicates the potential for recoverable injury of spawning herring. A partial overlap of the recoverable injury noise contour with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998) is apparent in Figure 6.12 to Figure 6.15, although, as shown by annual IHLS data (ICES, 2007-2020) the main spawning of Downs herring stock consistently occurs in the Eastern Channel, outside of the recoverable injury impact contours. Furthermore, suitable herring spawning substrates are widely distributed across the wider Thames Estuary and the English Channel.

6.11.112 There is no overlap of the recoverable injury noise contour with the Blackwater herring stock spawning ground, and therefore there will be no impact from piling on the spawning of the Blackwater herring stock.

6.11.113 With regards the temporal MDS, the maximum duration of piling results from the piling of 340 pin piles, resulting in a total piling time of 1,360 hours, within a 12-month piling campaign. In the context of the annual herring spawning period for the Downs and Blackwater herring spawning stock (November to January, Coull *et al.*, (1998)) over one year this equates to 61.6% respectively of the herring spawning period potentially impacted by piling noise. In the context of annual spawning periods for cod, whiting, sprat and horse mackerel (January to April, February to June, May to August, and March to August respectively) this equates to 47.6%, 38%, 46.4% and 30.9%, respectively. However, for all receptors this assumes that all piling will occur within the spawning periods and therefore the actual temporal impact on the receptors will be significantly less.

6.11.114 Considering the partial overlap of the recoverable injury noise contours with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998) (Figure 6.12 to Figure 6.15), the areas of low-density herring larvae present within the noise contour extents, the recoverable nature of the impact (therefore unlikely to result in any overall fitness effect at a population level) the magnitude of impact of recoverable injury from piling activities on spawning herring is considered to be **low**.

6.11.115 As there is no overlap of the recoverable injury noise contours of the Blackwater herring spawning ground (Figure 6.12 to Figure 6.15), the magnitude of impact from recoverable injury on the Blackwater herring stock from piling activities is considered to be **negligible**.

6.11.116 Considering the low and spatially discrete risk of interaction with seahorse, due to their low population numbers across the region, the magnitude of impact of recoverable injury on seahorse from underwater noise is considered to be **negligible**.

6.11.117 The predicted recoverable injury noise contours are spatially limited extent and there is no overlap with sea bass nursery areas. Therefore, the magnitude of impact of recoverable injury on sea bass within nursery areas within nursery areas from piling activities is considered to be **negligible**.

6.11.118 Spawning grounds for cod, whiting, sprat and horse mackerel are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local scale (based on the modelling results). The magnitude of impact of recoverable injury is therefore considered to be **low**.

6.11.119 All other Group 3 receptors are present in abundance within the region, and therefore any impacts from underwater noise are expected to be of local scale. Taking into consideration the broadscale distribution of these, and the intermittent nature of the piling activities, the maximum magnitude of impact from recoverable injury is expected to be **negligible**.

## SIGNIFICANCE OF EFFECT

6.11.120 The impact of recoverable injury on Downs stock herring, is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.121 The impact of recoverable injury on the Blackwater herring stock is considered to be of **negligible** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.122 The impact of recoverable injury on seahorse, is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **high**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.123 The impact of recoverable injury on seabass within nursery areas, is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.124 The impact of recoverable injury of spawning Group 3 receptors, is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.125 The impact of recoverable injury on all other Group 3 receptors, is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## RECOVERABLE INJURY OF EGGS AND LARVAE

### SENSITIVITY

6.11.126 Plaice, sole, cod, horse mackerel, sandeel, herring, mackerel, sprat, whiting and lemon sole all have spawning grounds within the vicinity of VE (Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report). Eggs and larvae are considered organisms of concern by Popper *et al*., (2014), due to their vulnerability, reduced mobility and small size, and are considered sensitive to particle motion generated by pile driving. Taking this into consideration and given the broadscale nature of the spawning grounds, the sensitivity of eggs and larvae to recoverable injury from underwater noise is considered to be **medium**.

### MAGNITUDE OF IMPACT

6.11.127 Taking into consideration the Popper *et al*., (2014) criteria, the extent of noise disturbance potentially causing recoverable injury of eggs and larvae would result in a **moderate** degree of disturbance at a near field distance from the source, and a **low** degree of disturbance in the near and far field.

6.11.128 Considering the Popper *et al*., (2014) qualitative criteria, there is the potential for recoverable injury of Downs herring stock eggs and larvae. However, peak densities of herring larvae are apparent within the eastern English Channel, outside of the anticipated impact range. Therefore there will be no population effect on herring from recoverable injury, and the magnitude of impact from piling activities on herring eggs and larvae is considered to be low.

6.11.129 Taking into consideration the Popper *et al*., (2014) qualitative criteria, and the distance of the Blackwater herring spawning ground from VE (Figure 6.6), recoverable injury is not anticipated to occur on Blackwater herring stock eggs and larvae, therefore the magnitude of impact from recoverable injury from piling activities is considered to be **negligible**.

6.11.130 Considering the broad distribution of all other receptors spawning grounds across the wider Thames estuary and southern North Sea, it is anticipated that there will be a barely discernible change from baseline conditions, therefore the magnitude of impact from recoverable injury on eggs and larvae from piling activities is considered to be low.

### SIGNIFICANCE OF EFFECT

6.11.131 The impact of recoverable injury on Downs herring stock eggs and larvae, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.132 The impact of recoverable injury on Blackwater herring stock eggs and larvae, is considered to be of **negligible** magnitude, and the sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.133 The impact of recoverable injury on all other receptor eggs and larvae, is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### RECOVERABLE INJURY OF SHELLFISH

6.11.134 There are no criteria for shellfish sensitivity to noise, and therefore a qualitative assessment has been undertaken using peer-reviewed literature in paragraph 6.11.76 *et seq.* which concluded shellfish to be of **low** sensitivity to underwater noise.

6.11.135 It is understood that particle motion attenuates rapidly, and therefore impacts on shellfish from particle motion are likely to occur local to the source. Taking this into account, and the broad distribution of these species along the UK coasts, and across the Thames estuary, the magnitude of effect on shellfish receptors is therefore considered to be low.

6.11.136 The impact of recoverable injury on shellfish is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### TEMPORARY THRESHOLD SHIFT (TTS)/ HEARING DAMAGE

6.11.137 Temporary threshold shift (TTS) is a temporary reduction in hearing sensitivity caused by exposure to intense sound. TTS has been demonstrated in some fishes, resulting from temporary changes in sensory hair cells of the inner ear and/or damage to auditory nerves. However, sensory hair cells are constantly added to fishes and are replaced when damaged and therefore the extent of TTS is of variable duration and magnitude. Normal hearing ability returns following cessation of the noise causing TTS, though this period is variable. When experiencing TTS, fish may have decreased fitness due to a reduced ability to communicate, detect predators or prey, and/or assess their environment. Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report presents the ranges at which TTS in fish may occur as a result of piling operations during the VE construction phase and these are drawn upon in the following assessment.

## TTS OF GROUP 1 RECEPTORS

### SENSITIVITY OF VERS

6.11.138 As noted previously in Table 6.20, sandeel are a Group 1 receptor (TTS onset at 186 dB $SEL_{cum}$), considered to be of **low** sensitivity to underwater noise, with spawning grounds located across the Southern North Sea. All other Group 1 receptors have **low** sensitivity to TTS from underwater noise impacts from piling activities.

### MAGNITUDE OF IMPACT

6.11.139 Regarding the piling of foundations at single locations (Table 6.17) the maximum predicted range of impact for TTS of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of up to four pin piles at a single location (hammer energy 3,000kJ) within a 24-hour period. An impact range of up to 39km is predicted from TTS from piling within the array areas for stationary Group 1 receptors. A TTS impact range of up to 28km is predicted from the piling of a single pin pile (hammer energy 3,000kJ). An impact range of up to 37km is predicted from the piling of a single monopile foundation (hammer energy 7,000kJ) within a 24 hour period for stationary Group 1 receptors.

6.11.140 Regarding the TTS impact ranges for fleeing receptors from the installation of foundations at single locations (Table 6.17), the predicted range of impact for TTS of fleeing Group 1 receptors occurs from the piling of one monopile at a single location (hammer energy 7,000kJ) in a 24 hour period. A TTS impact range of up to 23 km is predicted from this piling scenario within the array areas for fleeing Group 1 receptors. An impact range of up to 18km is predicted from the piling of a single pin pile in a 24-hour period (hammer energy 3,000kJ). A TTS impact range of up to 19km is predicted from the sequential piling of up to four pin piles within a 24 hour period for fleeing Group 1 receptors.

6.11.141 Regarding the sequential piling of foundations at multiple locations using a staggered approach (Table 6.18) the maximum predicted range of impact for TTS of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of up to two monopile foundations at both the north edge piling location (north array) and the southwest piling location (south array) (total four monopiles) (hammer energy 7,000kJ). A TTS impact area of up to 5,900km$^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. An impact area of up to 5200km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for stationary Group 1 receptors.

6.11.142 Regarding the TTS impact ranges for fleeing receptors from the sequential installation of foundations at multiple locations using a staggered approach (Table 6.18), the predicted maximum area of impact for TTS of fleeing Group 1 receptors results from the sequential piling of two monopiles (hammer energy 7,000 kJ)). An impact area of up to 1,200km$^2$ is predicted from this piling scenario within the array areas for fleeing Group 1 receptors. A TTS impact area of up to 840km$^2$ is predicted from the piling of up to four pin pile foundations (hammer energy 3,000kJ) for fleeing Group 1 receptors.

6.11.143 There is the potential for concurrent piling to be undertaken for pin piles or monopiles (Table 6.19). The worst-case TTS impact areas from concurrent piling will result from piling at the southwest corner of the southern array area, and the north edge location within the northern array area. The maximum in-combination area of effect of TTS on stationary Group 1 receptors results from the concurrent piling of two monopile foundations at both locations (total four monopiles). A TTS impact area of up to 5,900km$^2$ is predicted from this piling scenario within the array areas for stationary Group 1 receptors. A TTS impact area of up to 5,200km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ) for stationary Group 1 receptors.

6.11.144 The maximum in-combination area of effect of TTS on fleeing Group 1 receptors also results from the concurrent piling of two monopile foundations at both locations (Table 6.19). A TTS impact area of up to 2,400km$^2$ is predicted from this piling scenario within the array areas for fleeing Group 1 receptors. A TTS impact area of up to 1,900km$^2$ is predicted from the piling of up to four pin pile foundations at each location (total eight pin piles) (hammer energy 3,000kJ).

6.11.145 Sandeel are known to be present around a substantial proportion of the UK coast and have suitable habitats and spawning grounds that are correspondingly broad. Population effects on sandeel from TTS are not anticipated when the broad distribution of suitable spawning habitats across the Southern North Sea and more distant areas and the localised range of any injurious impacts are considered.

6.11.146 Spawning grounds for all other Group 1 receptors within the VE study area are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from TTS are considered to be of local scale (based on the modelling results).

6.11.147 With regards the temporal MDS, the maximum duration of piling results from the piling of 340 pin piles, resulting in a total piling time of 1,360 hours, within a 12-month piling campaign. In the context of the annual sandeel spawning period (November to February (Ellis *et al*., 2012)) over one year, this equates to 47.6% respectively of the sandeel spawning period potentially impacted by piling noise. In the context of annual spawning periods for common sole, lemon sole, plaice and mackerel (March to May; November to January; December to March; and May to August respectively), this equates to 63%, 63%, 47.6% and 46.1% of the spawning periods respectively. However, for all receptors this assumes that all piling will occur within the spawning periods and therefore the actual temporal impact on the receptors will be significantly less.

6.11.148 Given the broadscale nature of sandeel spawning grounds, and the intermittent nature of the piling activities, the impact magnitude for TTS on sandeel is considered to be **low** for both the spatial and temporal MDS.

6.11.149 Given the broadscale nature of all other Group 1 receptor spawning grounds, and the intermittent nature of the piling activities, the magnitude of impact for TTS on all other Group 1 receptors is therefore considered to be **low** for both the spatial and temporal MDS.

6.11.150 All other Group 1 receptors are present in abundance within the region, and therefore any impacts from underwater noise are expected to be of local scale. Given the broadscale distribution of these receptors and their spawning grounds, and the intermittent nature of the piling activities, the maximum magnitude of impact from TTS is expected to be **negligible**.

### SIGNIFICANCE OF EFFECT

6.11.151 The impact of TTS on sandeel is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.152 The impact of TTS on spawning Group 1 receptors is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.153 The impact of TTS on all other Group 1 receptors is considered to be of **negligible** magnitude, and the sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## TTS OF GROUP 2 RECEPTORS

### SENSITIVITY

6.11.154 As detailed in Table 6.21, Group 2 receptors (TTS onset at 186 dB $SEL_{cum}$) are considered to be of **low** sensitivity to underwater noise.

### MAGINITUDE OF IMPACT

6.11.155 Regarding the spatial MDS, the Popper *et al.* (2014) criteria for TTS of Group 2 receptors are the same as that of risk of TTS to fleeing Group 1 receptors (as detailed in paragraph 6.11.140 *et seq.*) and therefore the impact ranges presented for Group 2 receptors replicate those for Group 1 receptors.

6.11.156 Regarding the temporal MDS, Atlantic salmon and sea trout have the potential to be within range of injurious effects from piling noise, however these VERs are anticipated to be transient across the site, and therefore any temporal impacts on these receptors are anticipated to be minimal.

6.11.157 Taking into account the limited impact range anticipated on fleeing Group 2 receptors, and the transient nature of Atlantic salmon and sea trout across the site, the magnitude of impact from TTS on Group 2 receptors from the spatial and temporal MDS is considered to be low.

## SIGNIFICANCE OF EFFECTS

6.11.158 The impact of TTS Group 2 receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## TTS OF GROUP 3 RECEPTORS

## SENSITIVITY

6.11.159 As noted above in Table 6.22, spawning herring (Group 3 receptor, TTS onset at 186 dB $SEL_{cum}$) are considered to be of **medium** sensitivity. Seahorse (Group 3 receptor, TTS onset at 186 dB $SEL_{cum}$) however are of **high** sensitivity to underwater noise. All other Group 3 receptors are of **low** sensitivity to underwater noise impacts from piling activities.

## MAGINITUDE OF IMPACT

6.11.160 Regarding the spatial MDS for stationary Group 3 receptors, the Popper *et al*. (2014) criteria for TTS of Group 3 receptors are the same as that of risk of TTS to Group 1 receptors (as detailed in paragraph 6.11.139 *et seq*.) and therefore the impact ranges presented for Group 3 receptors replicate those for Group 1 receptors, both for fleeing and stationary receptors.

6.11.161 The noise contours shown in relation to herring spawning grounds and larvae abundances (Coull *et al*., 1998 and IHLS data (2007 – 2020)) in Figure 6.12 to Figure 6.15, indicate the potential for TTS of spawning herring. As shown by annual IHLS data (ICES, 2007-2021 (Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data)), the main spawning activity of the Downs stock, occurs in the Eastern Channel (as informed by relative larvae abundances), outside of the TTS impact range contours. Furthermore, suitable herring spawning substrates are widely distributed across the wider Thames Estuary and the English Channel. Therefore, there will be no population level impact from TTS from piling on the spawning of the Downs herring stock.

6.11.162 There is no overlap of the TTS noise contour with the Blackwater herring stock spawning ground, and therefore there will be no population level impact from TTS on the spawning of the Blackwater herring stock.

6.11.163 With regards the temporal MDS, the maximum duration of piling results from the piling of 340 pin piles, resulting in a total piling time of 1,360 hours, within a 12-month piling campaign. In the context of the annual herring spawning period for the Downs and Blackwater herring spawning stock (November to January, Coull *et al*., (1998)) over one year this equates to 61.6% respectively of the herring spawning period potentially impacted by piling noise. In the context of annual spawning periods for cod, whiting, sprat and horse mackerel (January to April, February to June, May to August, and March to August respectively) this equates to 47.6%, 38%, 46.4% and 30.9%, respectively. However, for all receptors this assumes that all piling will occur within the spawning periods and therefore the actual temporal impact on the receptors will be significantly less.

6.11.164 Considering the partial overlap of the TTS noise contours with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), the areas of low-density herring larvae present within the noise contour extents, and the temporary and recoverable nature of the impact (therefore unlikely to result in any overall fitness effect at a population level) the magnitude of impact of TTS from piling activities on spawning herring is considered to be **low**.

6.11.165 There is no overlap of the TTS noise contours with the Blackwater herring stock spawning ground, therefore the magnitude of impact from TTS is **negligible**.

6.11.166 Considering the low and spatially discrete risk of interaction with seahorse, due to their low population numbers across the region, the magnitude of impact on seahorse from TTS is considered to be **negligible**.

6.11.167 Considering the spatially limited extent of the noise contours, there is no overlap with sea bass nursery areas, and therefore the magnitude of impact of sea bass within nursery areas from piling activities is considered to be **negligible**.

6.11.168 Spawning grounds for cod, whiting, sprat and horse mackerel are widely distributed across the wider Thames estuary and the southern North Sea and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local scale (based on the modelling results). All other Group 3 receptors are present in abundance within the region, and therefore any impacts from underwater noise are expected to be of local scale. Given the broadscale distribution of these receptors and their spawning grounds, and the intermittent nature of the piling activities, the maximum magnitude of impact from TTS is expected to be **low**.

## SIGNIFICANCE OF EFFECT

6.11.169 The impact of TTS of spawning Downs stock herring is considered to be of **high** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.170 The impact of TTS of spawning Blackwater stock herring is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse,** which is not significant in EIA terms.

6.11.171 The impact of TTS of seahorse is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be high. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.172 The impact of TTS on seabass, is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.173 The impact of TTS on spawning Group 3 VERs is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.174 The impact of TTS on all other Group 3 VERs is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## TTS OF EGGS AND LARVAE

6.11.175 Impacts on eggs and larvae were assessed using the Popper *et al*., (2014) criteria, in terms of risk of recoverable injury in paragraph 0 *et seq*. The Popper *et al*., (2014) criteria for TTS are the same, and therefore the impact assessment for eggs and larvae replicates that undertaken for recoverable injury in paragraph 0 *et seq*. Eggs and larvae were assessed as having **medium** sensitivity to underwater noise impacts, with a **moderate** degree of disturbance at a near field distance from the source predicted on the receptors.

6.11.176 The impact of TTS of eggs and larvae is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## TTS OF SHELLFISH

6.11.177 There are no criteria for shellfish sensitivity to noise, and therefore a qualitative assessment has been undertaken using peer reviewed literature. On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure (e.g,. Popper and Hawkins, 2018). As the understanding of marine invertebrate sensitivity to particle motion is in its infancy (Lewandowski *et al*., 2016), there is limited information available on the potential for hearing damage on shellfish from particle motion. However, a study by Zhang *et al*., (2015) did suggest that severe particle motion could irreparably damage the statocysts of cephalopods at short range, causing hearing impairment. This was considered likely to occur as a result of pile driving, although thought to only occur at short range. Taking this into account, shellfish are considered to be of **low** sensitivity to underwater noise impacts.

6.11.178 It is understood that particle motion attenuates rapidly, therefore any impacts on shellfish are likely to be localised. Taking this into account, and the broad distribution of these species along the UK coasts, and across the wider Thames estuary, the magnitude of magnitude of effect on shellfish receptors is assessed as low.

6.11.179 The impact of TTS of shellfish is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## BEHAVIOURAL IMPACTS

6.11.180 Different fish and shellfish have varying sensitivities to piling noise, depending on how these species perceive sound in the environment. Behavioural effects in response to construction related underwater noise include a wide variety of responses including startle responses (C-turn), strong avoidance behaviour, changes in swimming or schooling behaviour, or changes of position in the water column (e.g., Hawkins *et al*., 2014a). Depending on the strength of the response and the duration of the impact, there is the potential for some of these responses to lead to significant effects at an individual level (e.g., reduced fitness, increased susceptibility to predation) or at a population level (e.g., avoidance or delayed migration to key spawning grounds), although these may also result in short-term, intermittent changes in behaviour that have no wider effect, particularly once acclimatisation to the noise source is taken into account.

6.11.181 Regarding Group 1 fish and shellfish, these receptors lack a swim bladder, and so are largely considered to be less sensitive to sound pressure, with these species instead detecting sound in the environment through particle motion. The sensitivity of the receptors to acoustic particle velocity component of the sound field has been noted by a number of researchers (Hawkins, 2006; Nedwell *et al*., 2007; Popper and Hastings, 2009) and the potential for piling activity to generate the type of sound fields that may contain substantial acoustic particle velocity components has also been noted in the literature (Hawkins, 2009). As such, sensitivity to particle motion in the Group 1 fish receptors and shellfish is more likely to be important for behavioural responses rather than injury (Hawkins, 2009; Hawkins *et al*., 2014a; Mueller-Blenkle *et al*., 2010).It has also been reported that slow, rolling interface waves that move out from a source like a pile driver can produce particle motion amplitudes travelling considerable distances (Hawkins and Popper, 2016), with implications for demersal and sediment dwelling fish (such as sandeel) and shellfish in close proximity to piling operations. Specifically, demersal dwelling receptors such as sandeel (Group 1 receptors) may be particularly affected by vibration through the seabed during winter hibernation when sandeel remain buried in sandy sediments.

6.11.182 However, as indicated by the risk criteria outlined for Group 1 in Table 6.16, particle motion generated from piling is expected to attenuate more rapidly than the acoustic pressure component in the water, with a low risk of behavioural effects in the far-field (i.e., kilometres from the source).

6.11.183 Mueller-Blenkle *et al*. (2010) measured behavioural responses of Dover sole to sounds representative of those produced during marine piling, with considerable variation across subjects (i.e., depending on the age, sex, condition etc. of the fish, as well as the possible influence of confinement in cages on the overall stress levels in the fish). This study concluded that it was not possible to find an obvious relationship between the level of exposure and the extent of the behavioural response, although an observable behavioural response was reported at 144 to 156dB re 1 µPa SPLpeak for Dover sole. However, this threshold should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this, especially considering the varied responses observed across subjects.

6.11.184 Research into the impact of underwater noise on shellfish receptors is scarce, and no attempt has been made to set exposure criteria (Hawkins *et al*., 2014b). Studies on marine invertebrates have shown sensitivity of shellfish receptors to substrate borne vibration (Roberts *et al*., 2016). Aquatic decapod crustaceans are equipped with a number of receptor types potentially capable of responding to the particle motion component of underwater noise (e.g., the vibration of the water molecules which results in the pressure wave) and ground-borne vibration (Popper *et al*., 2001). It is generally their hairs that provide the sensitivity, although these animals also have other sensor systems which could be capable of detecting vibration.

6.11.185 Group 2, 3 and 4 fish receptors possess a swim bladder and therefore are more sensitive to the sound pressure components of underwater noise, therefore the risks of behavioural effects are considered greater for these species. A number of studies have examined the behavioural effects of the sound pressure component of impulsive noise (including piling operations and seismic airgun surveys) on fish species, including Group 3 gadoids. Mueller-Blenkle *et al*. (2010) measured behavioural responses of cod to sounds representative of those produced during marine piling and observed behavioural responses at 140 to 161 dB re 1 µPa SPLpeak for cod. However, variable responses were observed across subjects and consequently this threshold should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this. A study by Pearson *et al*. (1992) on the effects of seismic airgun noise on caged rockfish (*Sebastes species*) observed a startle or C-turn response at peak pressure levels beginning around 200dB re 1 µPa, although this was less common with the larger fish. Studies by Curtin University in Australia for the oil and gas industry by McCauley *et al*. (2000) exposed various fish species in large cages, in open water to seismic airgun noise and assessed behaviour, physiological and pathological changes. The study made the following observations:

- a general fish behavioural response to move to the bottom of the cage during periods of high-level exposure (greater than root mean square (RMS) levels of around 156 to161 dB re 1 µPa; approximately equivalent to SPLpeak levels of around 168 to 173 dB re 1 µPa);
- a greater startle response by small fish to the above levels;
- a return to normal behavioural patterns some 14 to 30 minutes after airgun operations ceased;

- no significant physiological stress increases attributed to air gun exposure; and
- some preliminary evidence of damage to the hair cells when exposed to the highest levels, although it was determined that such damage will only likely occur at short range from the source.

6.11.186 The authors did, however, note that any potential seismic effects on fish may not necessarily translate to population scale effect or disruption to fisheries and McCauley *et al*. (2000) show that caged fish experiments can lead to variable results.

6.11.187 Picciulin *et al*., (2022) undertook a study based on free-living brown meagre (*Sciaena umbra*) fish and observed no influence on breeding site selection of brown meagre fish when exposed to vessel noise. Similar observations were made by Bruintjes *et al*., (2014), who observed no influence on the early-life survival and growth of the cichlid fish (*Neolsmprologus pulcher*) when exposed to moderate noise increases (motorboat noise). Although it should be noted that this study was conducted on captive fish.

6.11.188 Hawkins *et al*. (2014a) undertook a study on schools of sprat and mackerel, observing behavioural responses to pile driving. A range of responses were observed at sound pressure levels (SPL) of 163.2 SPLpeak-to-peak and estimated single strike SEL of 135dB re 1 µPa2 s for sprat and 163.3dB re 1µPa peak-to-peak and estimated single strike SEL 142.0dB re 1µPa2 s for mackerel. Although responses were found to vary (to the same stimulus type and intensity), differing between the two species, schooling fish and individuals, and during night and day. However, it should be acknowledged that this threshold is based on a study undertaken within a quiet loch on fish not involved in any particular activity (i.e. not spawning), and it is therefore not considered appropriate to apply the outcomes of this study to a much noisier area such as the southern North Sea (which is subject to high levels of anthropogenic activity and consequently noise) as the fish within this area will be acclimated to the noise and would be expected to have a correspondingly lower sensitivity to noise levels.

6.11.189 Acoustic trauma has been observed in selected cephalopod species, as evidenced by André *et al*. (2011) who observed acoustic trauma in European squid, following exposure to low frequency sound. This was also observed by Samson *et al*. (2016) with a range of behavioural responses to underwater noise in cephalopods recorded, including inking, colour changes and startle responses. However, Fewtrell and McCauley (2012) suggest that such alterations are only temporary from experimental studies.

6.11.190 Seahorse hearing is considered similar to that of herring (Group 3) and are therefore likely to be sensitive to underwater noise. A study on wild spiny/long snouted seahorse, found 87% of seahorse reacted to a noise stimulus (expressed by increased opercular movements per minute (OMPM)) during the induced sequence of transient (up to 127.6dB) and constant (137.1dB) sound exposure (Palma *et al*., 2019). In addition, Palma *et al*., (2019) also found <38% of those seahorses abandoned their holdfast and moved away, a behaviour the authors are interpreting as an attempt to avoid the negative sound stimuli. A study by Anderson *et al*. (2011) examined the behavioural response of the lined seahorse (*Hippocampus erectus*) when exposed to 123dB to 137dB rms re 1µPa in a tank for a month. Seahorse exposed to loud noises showed a behavioural response such as irritation and distress, and a physiological response, including lower weight, worse body condition, higher plasma cortisol and other blood measures indicative of stress, and more parasites in their kidneys. In addition to the primary and secondary stress indices in the blood and plasma, seahorses exhibited tertiary indices (e.g., growth, behaviour, and mortality) (Anderson *et al*., 2011). However, the study found that some of the variability in these measures (such as time spent mobile) subsided after the first week, presumably due to habituation. It is important to note that Radford *et al*. (2016) recorded shipping sound levels of 124dB rms re 1µPa, seismic survey noise levels at 131dB rms, and pile driving at 141dB rms; in this context and based on the Anderson *et al*. (2011) paper, seahorses can be expected to habituate to the noise levels that may be experienced during piling operations.

6.11.191 The European seabass has increasingly been used in the study of anthropogenic noise effects on fish. The hearing sensitivity of seabass is most acute at low frequencies (100–1000 Hz); coincident with many anthropogenic noises in water (Götz *et al*., 2009). Spiga *et al*., (2017) investigated the effects of recordings of piling and drilling noise on the anti-predator behaviour of captive juvenile European seabass in response to a visual stimulus (a predatory mimic). None of the behavioural measures related to exploration, swimming activity or anxiety were affected by playback noise onset (Spiga *et al*., 2017).

6.11.192 Exploration behaviour is an important feature in fish as it leads to finding food, mates and escapes routes. Therefore, it has been suggested that although piling noise triggers reflex behaviours, the responses would appear not to be detrimental to the fish (Spiga *et al*., 2017). It is, therefore, reasonable to assume that this species is able to detect both particle motion and pressure changes of the sound (Radford *et al*., 2012). If seabass are close to the seabed, they may well be affected by seabed vibration (Hazelwood, 2012; Hazelwood and Macey, 2016a, 2016b). Research by Radford *et al*., (2016) using seabass was designed to examine the changes in ventilation rate (opercular beat rate (OBR)) caused by noise to captive fish, which would indicate a stress response. When pile driving noise was played at 147dB SELss, 30dB above the ambient noise played prior to the stimulus (117dB SPLRMS), a clear increase in OBR was detected. Additional research by Kastelein *et al*., (2017), also on seabass, identified that initial responses in adult fish (sudden short-lived changes in swimming speed) occurred in response to impulsive pile driving at 141dB SELss, but concluded that no sustained responses (changes in school cohesion, swimming depth, and speed) occurred at levels up to 166dB SELss. Kastelein *et al*., (2017) concluded that the analysis showed that there is no evidence, even at the highest sound level, for any consistent sustained response to sound exposure by the study animals. A study undertaken by Neo *et al.*, (2018) on captive seabass, observed more significant behavioural responses of European bass to piling during the night than during the day, and also noted habituation over repeated sound exposure.

6.11.193 While these studies are informative to some degree, these, and other similar studies, do not provide an evidence base that is sufficiently robust to propose quantitative criteria for behavioural effects (Hawkins and Popper, 2016; Popper *et al.*, 2014). Nonetheless, the quantitative criteria identified in the literature have been summarised below, for ease of the reader:

**Table 6.23: Summary of behavioural noise response thresholds identified in literature**

| Literature | Receptor | Behavioural response threshold identified |
|---|---|---|
| Mueller-Blenkle *et al.* (2010) | Dover sole | 144 to 156 dB re 1 µPa $SPL_{peak}$ |
| Mueller-Blenkle *et al.* (2010) | Cod | 140 to 161 dB re 1 µPa $SPL_{peak}$ |
| Pearson *et al.* (1992) | Rock fish | 200 dB re 1 µPa (mean-peak level) |
| McCauley *et al.* (2000) | N/A | 156 to 161 dB re 1 µPa rms, 168 to 173 dB re 1 µPa SPLpeak |
| Hawkins *et al.* (2014a) | Sprat | 163.2 dB re 1 µPa SPLpeak, 135 dB re 1 µPa SELss |
| Hawkins *et al.* (2014b) | Mackerel | 163.3 dB re 1 µPa SPLpeak, 142.0 dB re 1 µPa SELss |
| Anderson *et al.* (2011) | Seahorse | 123 dB to 137 dB re 1 µPa rms |
| Radford *et al.* (2016) | Seabass | 147 dB re 1 µPa SELss |
| Kastelein *et al.* (2017) | Seabass | 141 dB re 1 µPa SELss |

6.11.194 As evidenced by the studies above, fish and shellfish behavioural responses to underwater noise are highly dependent on factors such as the type of fish/shellfish, sex, age and condition, as well as other stressors to which the fish/shellfish have been exposed. For example, it is expected that smaller fish might show behavioural responses at lower levels of noise. In addition to this, the response of the fish will depend on the reasons and drivers for the fish being in the area. Foraging or spawning, may increase the desire for the fish to remain in the area despite the elevated noise level (Peña *et al.*, 2013). This is supported by Neo *et al.* (2014) who concluded that a single criterion value for behaviour does not take into consideration the substantial species differences in behaviour, nor does it take into consideration response changes with animal age, season, or motivational state. This is evidenced by Skaret *et al*., (2005) who observed no avoidance behaviours in herring, in response to vessel noise when engaged in spawning behaviours.

6.11.195 The thresholds identified in the literature detailed above and summarised in Table 6.23, are largely based on captive animals (as reviewed by Popper and Hawkins, 2019). Whilst studies on captive animals are suitable for gaining physiological information such as hearing sensitivity, they may not be suitable for understanding how a wild animal will respond behaviourally to a stimulus (Oldfield, 2011). Notably, a need for further research on behavioural responses to external stimuli was highlighted by Popper *et al*., (2014) with an emphasis on the requirement for studies on wild fish receptors.

6.11.196 Due to the range of behavioural responses elicited from fish and shellfish receptors, and the influence from environmental variables and ecological stressors, Popper *et al*., (2014) recommend the application of a qualitative assessment. The qualitative behavioural criteria derived from Popper *et al*. (2014) for fish are provided in Table 6.24 below. These categorise the risks of effects in relative terms as 'high, moderate or low' at three distances from the source: near (10s of metres), intermediate (100s of metres), and far (1,000s of metres), respectively. This qualitative approach as recommended by Popper *et al*. (2014) has been applied to the assessment of behavioural impacts of fish and shellfish below.

**Table 6.24: Qualitative behavioural criteria (Popper et al, 2014)**

| **Type of animal** | **Impairment** | |
|---|---|---|
| | **Auditory masking** | **Behaviour** |
| Fish: no swim bladder (Group 1) | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) Moderate<br>(F) Low |
| Fish: swim bladder is not involved in hearing (Group 2) | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) Moderate<br>(F) Low |
| Fish: swim bladder involved in hearing (Group 3 and 4) | (N) High<br>(I) High<br>(F) Moderate | (N) High<br>(I) High<br>(F) Moderate |
| Eggs and larvae | (N) Moderate<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low |
| Risk of effect category (high, moderate low) is given at three distances from the source in relative terms: near field (N: 10s of metres), intermediate field (I: 100s of metres), and far field (F: 1,000s of metres); (Popper *et al*., 2014). | | |

## BEHAVIOURAL IMPACTS OF GROUP 1 RECEPTORS

### SENITIVITY OF GROUP 1 VERS

6.11.197 As noted previously in Table 6.20, sandeel are considered to be of **low** sensitivity to underwater noise. All other Group 1 receptors are considered to be of **low** sensitivity to underwater noise.

### MAGNITUDE OF IMPACT

6.11.198 Considering the Popper *et al*., (2014) criteria, any risk of behavioural effects or auditory masking in Group 1 species (particularly the less mobile species) from piling are expected to be **low** in the intermediate field. Near field behavioural impacts are considered likely to be fully contained within TTS effects and so are not considered further. Taking this into consideration, the magnitude of impact from behavioural effects on Group 1 species is considered to be low.

### SIGNIFICANCE OF EFFECT

6.11.199 The impact of behavioural effects of Group 1 VERs is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect from behavioural effects is therefore concluded to be a maximum of **minor adverse**, which is not significant in EIA terms.

## BEHAVIOURAL IMPACTS OF GROUP 2 RECEPTORS

### SENITIVITY OF GROUP 2 VERS

6.11.200 As noted previously in Table 6.21, Group 2 receptors are considered to be of **low** sensitivity to underwater noise.

### MAGNITUDE OF IMPACT

6.11.201 Considering the Popper *et al*., (2014) criteria, any risk of behavioural effects or auditory masking in Group 2 species from piling are expected to be **low** in the intermediate field. Near field behavioural impacts are considered likely to be fully contained within TTS effects and so are not considered further. Atlantic salmon and sea trout are considered unlikely to be within range of any behavioural impacts from piling noise as these VERs are anticipated to be transient across the site. Any temporal impacts on these receptors are therefore anticipated to be minimal. Therefore, the magnitude of the impact behavioural effects on Group 2 receptors from the temporal MDS is considered to be low.

### SIGNIFICANCE OF EFFECT

6.11.202 The impact of behavioural effects of Group 2 VERs is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect of behavioural effects is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## BEHAVIOURAL IMPACTS OF GROUP 3 RECEPTORS

### SENITIVITY OF GROUP 3 VERS

6.11.203 As noted previously in Table 6.22, spawning herring are of **medium** sensitivity to underwater noise, and seahorse are of **high** sensitivity to underwater noise. All other Group 3 receptors are considered to be of **low** sensitivity.

### MAGNITUDE OF IMPACT

6.11.204 Spawning grounds for a number of Group 3 species overlap with the VE site or are within the wider area. Whilst the Popper *et al*., (2014) criteria suggest a **high** risk of behavioural disturbance in the intermediate field and a **moderate** risk in the far field, the risk assessment is likely to predicated on the individuals not being involved in activities with a strong biological driver (i.e., spawning or feeding). Specifically, Skaret *et al*., (2005) identified that spawning herring (a Group 3 species), had a significantly reduced reaction to external stimulus when involved in spawning activity than when swimming. As such, it is likely that any behavioural impacts to fish would be significantly reduced when spawning, with consequently limited impact on spawning potential for the relevant species.

6.11.205 However, as detailed in Table 10.4, following stakeholder engagement, the noise impact threshold as identified by Hawkins et al. (2014) for sprat, has been deemed applicable when describing the potential for behavioural effects in herring, as it focuses on species from the Clupeidae family. This threshold is shown Figure 6.16 to Figure 6.19, to inform the assessment and estimate the potential impact ranges of behavioural effects on herring. As evident in Figure 6.22, there is an overlap of the impact contour with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), however shown by annual IHLS data (ICES, 2007-2020 (Volume 6, Part 5, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data)), the main spawning activity of the Downs stock, occurs in the Eastern Channel (as informed by relative larvae abundances), outside of the impact range contours. It is also important in this context however to note that the use of the 135 dB SEL threshold in an open water receiving environment characterised by shipping is highly precautionary and very unlikely to elicit a comparable response to that observed by Hawkins et al. (2014.) Nonetheless, behavioural effects on a spawning population have the potential to lead to disruption to spawning behaviours, and therefore taking into account the proximity of the historic Downs herring spawning ground (as defined by Coull *et al*., 1998) to the proposed piling activities, and the significant overlap of the 135 dB SEL contour with the spawning ground, the magnitude of impact on spawning Downs herring from behavioural disturbance is considered to be **medium**.

6.11.206 There is no overlap of the 135 dB SEL threshold noise contour with the Blackwater herring stock spawning ground, therefore the magnitude of impact of behavioural effects is **negligible**.

6.11.207 Considering the low and spatially discrete risk of interaction with seahorse, due to their low population numbers across the region, the magnitude of impact of behavioural effects on seahorse from underwater noise is considered to be **negligible**.

6.11.208 There is no overlap with sea bass nursery areas, and therefore the magnitude of impact of behavioural effects on sea bass within nursery areas from piling activities is considered to be **negligible**.

6.11.209 The magnitude of impact of behavioural effects on all other Group 3 receptors is considered to be **low**.

### SIGNIFICANCE OF EFFECT

6.11.210 The impact of behavioural effects of spawning herring are considered to be of **medium** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect of behavioural effects is therefore concluded to be **moderate adverse**, which is significant in EIA terms.

6.11.211 The impact of behavioural effects of seahorse are considered to be of **negligible** magnitude, and the sensitivity of the receptor is considered to be **high**. The significance of the residual effect of behavioural effects is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.212 The impact of behavioural effects on seabass within nursery areas, are considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be low. The significance of the residual effect of behavioural effects is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.213 The impact of behavioural effects of all other Group 3 receptors are considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be low. The significance of the residual effect of behavioural effects is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## EGGS AND LARVAE

6.11.214 Given the considered stationary nature of eggs and larvae the potential for behavioural impacts is considered limited. As such, it is considered that the assessment of behavioural impacts to eggs and larvae is sufficiently captured within consideration of TTS for this group.

## SHELLFISH VERS

### SENSITIVITY OF SHELLFISH VERS

6.11.215 There are no criteria for shellfish sensitivity to noise, and therefore, a qualitative assessment has been undertaken based on published literature. Shellfish are considered a potential sensitive receptor to particle motion from piling, due to typically having low motility, and therefore are considered unlikely to be able to vacate the area at the onset of ‘soft-start piling’; Roberts (2015) suggested that vibroacoustic stimuli may elicit and affect anti-predator responses, such as startle response in crabs and valve closure in mussels. Such responses would effectively be distractions from routine activities such as feeding. Behavioural changes in mussels have also been observed in response to simulated pile-driving, with increased filtration rates observed in blue mussels (Spiga *et al*., 2016). In addition to this, Samson *et al*., (2016) recorded a range of behavioural responses to underwater noise in cephalopods, including inking, colour changes and startle responses. Taking this into consideration, shellfish were considered to be of **low** sensitivity to underwater noise impacts.

### MAGNITUDE OF IMPACT

6.11.216 It is understood that particle motion attenuates rapidly, and therefore impacts on shellfish from particle motion are likely to occur local to the source. Taking this into account, and the broad distribution of these species within the southern North Sea and along UK coasts, the magnitude of impact of behavioural effects on shellfish is considered to be low.

### SIGNIFICANCE OF EFFECT

6.11.217 The impact of behavioural effects of shellfish is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be low. The significance of the residual effect of behavioural effects is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### BARRIER EFFECTS FROM NOISE AND VIBRATION ON MIGRATING HERRING

6.11.218 The Downs herring stock migrates in a clockwise circuit in the North Sea, migrating from the northeast to the Downs spawning ground to the southeast, and then continuing in a northerly direction (Cushing, 2001). VE lies within the migration pathway for herring, however, is positioned on the northeastern return leg of the herring migration pathway. Therefore, it is not considered that piling would have any impacts on herring migration to the spawning grounds.

### OVERALL SIGNIFICANCE OF EFFECTS OF MORTALITY AND POTENTIAL MORTAL INJURY, RECOVERABLE INJURY, AND TTS ON FISH AND SHELLFISH RECEPTORS

6.11.219 When considering the combined effects of mortality and potential mortal injury, recoverable injury, TTS and behavioural impacts, the effects from underwater noise on spawning herring are considered to be of **moderate adverse** significance. In response to this conclusion, a seasonal piling restriction for spawning herring has been proposed, during the peak spawning period (6 November – 1 January) (see Section 6.10). This measure will be secured in a DML condition. Following the implementation of the proposed additional mitigation measure, the significance of the effect will be reduced to **minor adverse** which is not significant in EIA terms.

6.11.220 When considering the combined effects of mortality and potential mortal injury, recoverable injury, TTS and behavioural impacts, the effects from underwater noise on all other fish and shellfish receptors are considered to be of **minor adverse** significance, which is not significant in EIA terms.

## NOISE AND VIBRATION ARISING FROM UXO CLEARANCE IN THE ARRAY AREAS AND OFFSHORE ECC

6.11.221 With regards the seabed clearance works associated with UXO, as detailed in Table 6.10, as part of the site preparation activities for VE, UXO clearance may be required. Presence of UXO within the Proposed Order Limits (POL) can be managed in a number of ways: avoidance (through micrositing), non-destructive clearance through moving or removal of the UXO, or destructive clearance (i.e., *in-situ* detonation).

6.11.222 If required, destructive UXO clearance through detonation of the UXO can introduce a further underwater noise effect-receptor pathway that may result in an effect on noise sensitive receptors. Any UXO clearance would be completed within the VE array areas and offshore ECC, as part of the pre-construction site preparatory works. Until detailed pre-construction surveys are undertaken across the VE array areas and offshore ECC, the exact number of potential UXO which will need to be cleared is unknown.

6.11.223 The Applicant is not applying for consent for UXO clearance works as part of this DCO application (as at this stage it is not clear if it will be required, or indeed if required to what extent and location, and a separate Marine License will be sought for such works once these factors have been established). However, it is acknowledged that such UXO clearance could occur and therefore, it is appropriate to consider the potential impacts of this additional source of underwater noise on fish and shellfish species.

6.11.224 UXO clearance activities are one of the loudest anthropogenic noise sources that occur underwater, with typically much higher source levels than those from piling. UXO clearance is expected to result in mortality, mortal injury, recoverable injury, TTS and disturbance to fish and shellfish species, depending on the proximity of the individuals to the UXO location and the size of the UXO. Small scale mortality of fish as a result of UXO detonation are frequently recorded (Dahl *et al.*, 2020), with dead fish recorded floating at the surface following the detonation by Marine Mammal Observers in accordance with the JNCC (2010) guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC, 2010). The recordings for dead fish are typically made within the immediate vicinity of the detonation (Dahl *et al.*, 2020) and as such this is expected to be a small-scale impact.

6.11.225 Injury and disturbance effects will impact a progressively larger area, with TTS and disturbance effects potentially reaching 10's of kilometres from the UXO location. For an estimated of underwater noise levels and associated impact ranges from UXO detonation, see Volume 6, Part 5, Annex 6.2: Underwater Noise Technical Report.

6.11.226 Due to the potential impacts from underwater noise from UXO clearance, bubble curtains have in some cases been used for UXO clearance works to reduce the sound level received by marine animals from the detonation. While the primary driver for the deployment of bubble curtains is legislation protecting marine mammals, where bubble curtains are used, they will also result in a reduction of the impacts to fish and shellfish receptors as well. Recently, a new technique to the commercial sector for UXO clearance has been promoted: deflagration or “low order” detonation. This method, while currently untested in the commercial offshore wind sector, is being explored at an industry level and by government regulators as an alternative to standard techniques; evidence to date (e.g., Cheong *et al*., 2020) suggests a much quieter, standard source level (regardless of UXO charge size, with the sound level emitted only relating to the donor charge size) which is anticipated to result in reduced impacts on the marine environment.

6.11.227 It is possible that UXO operations will be planned to take place year-round during the UXO clearance campaign pre-construction and therefore have the potential to interact with the spawning period for different fish and shellfish species. However, each UXO clearance is a discrete event and while this may result in some temporary disturbance to spawning fish, it is less likely to result in the displacement of fish from specific spawning grounds, compared to more continuous noise sources such as piling.

6.11.228 While individual UXO detonations have the potential to result in greater impact ranges than a piling event, the discrete nature of a UXO detonation is considered to result in a lesser overall effect on fish and shellfish species populations. A full assessment of the potential impacts from UXO clearance works will be submitted to support a separate Marine License application prior to undertaking UXO clearance works at VE, once the full number of potential UXO and the likely sizes of these UXO are known, following further surveys which will only be undertaken once consent for VE is granted.

### OFFSHORE ECC IMPACTS

6.11.229 It may be necessary to install three sheet piled exit pits for the trenchless installation techniques within the landfall. The installation of the sheet piled exit pits will consist of the piling of up to 660, 750 mm wide Larssen sheet piles, using a maximum blow energy of 300 kJ. It is assumed that as a worst case up to eight piles will be sequentially installed in a 24-hour period. Underwater noise modelling for the piling at Mean High Water Springs (MHWS) and at Mean Low Water Springs (MLWS) was undertaken to determine the worst-case impact ranges for fish receptors. The modelling parameters are summarised in Table 6.25 below, and the outputs are detailed in full in Volume 6, Part 5, Annex 6.2: Underwater Noise Report.

**Table 6.25: MDS for sheet pile installation at landfall.**

| Parameter | Piling Scenario | |
|---|---|---|
| | **Single piling** | **Sequential piling** |
| **MHWS (4.6 m above LAT)** | | |
| Installation Approach | Piling of 1 sheet pile within a 24-hour period. | Piling of 8 sheet piles within a 24-hour period. |
| Sheet diameter | 750 mm | 750 mm |
| Hammer Energy (maximum) | 300 kJ | 300 kJ |
| Piling duration | 1 hour | 8 hours |
| **MLWS (0.1 m above LAT)** | | |
| Installation Approach | Piling of 1 sheet pile within a 24-hour period. | Piling of 8 sheet piles within a 24-hour period. |
| Sheet diameter | 750 mm | 750 mm |
| Hammer Energy (maximum) | 300 kJ | 300 kJ |
| Piling duration | 1 hour | 8 hours |

**Table 6.26: Noise modelling results for injury ranges for fleeing and stationary receptors for sheet piling.**

| Receptor | Criteria | Noise Level * | Single sheet pile installation | | Sequential piling of 8 sheet piles | |
|---|---|---|---|---|---|---|
| | | | MHWS | MLWS | MHWS | MLWS |
| **Mortality or Potential Mortal Injury** | | | | | | |
| Group 1 fish | $SPL_{peak}$ | 213 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 219 | < 100 m | < 100 m | < 100 m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 219 | < 100 m | < 100 m | < 100 m | < 100 m |
| Group 2 fish | $SPL_{peak}$ | 207 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 210 | < 100 m | < 100 m | < 100 m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 210 | < 100 m | < 100 m | < 100 m | < 100 m |
| Group 3 fish | $SPL_{peak}$ | 207 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 207 | < 100 m | < 100 m | < 100 m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 207 | < 100 m | < 100 m | < 100 m | < 100 m |
| Eggs and larvae | $SPL_{peak}$ | 207 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 210 | < 100 m | < 100 m | < 100 m | < 100 m |

| Receptor | Criteria | Noise Level * | Single sheet pile installation | | Sequential piling of 8 sheet piles | |
|---|---|---|---|---|---|---|
| | | | MHWS | MLWS | MHWS | MLWS |
| **Recoverable Injury** | | | | | | |
| Group 1 fish | $SPL_{peak}$ | 213 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 216 | < 100 m | < 100 m | < 100 m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 216 | < 100 m | < 100 m | < 100 m | < 100 m |
| Group 2 fish | $SPL_{peak}$ | 207 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 203 | < 100 m | < 100 m | < 100 m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 203 | < 100 m | < 100 m | < 100 m | < 100 m |
| Group 3 fish | $SPL_{peak}$ | 207 | < 50 m | < 50 m | < 50 m | < 50 m |
| | $SEL_{cum}$ (static) | 203 | < 100 m | < 100 m | < 100 m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 203 | < 100 m | < 100 m | < 100 m | < 100 m |
| **TTS** | | | | | | |
| Group 1 fish | $SEL_{cum}$ (static) | 186 | 160 m | < 100 m | 460m | < 100 m |

| Receptor | Criteria | Noise Level * | Single sheet pile installation | | Sequential piling of 8 sheet piles | |
|---|---|---|---|---|---|---|
| | | | MHWS | MLWS | MHWS | MLWS |
| | $SEL_{cum}$ (fleeing) | 186 | < 100 m | < 100 m | < 100 m | < 100 m |
| Group 2 fish | $SEL_{cum}$ (static) | 186 | 160 m | < 100 m | 460m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 186 | < 100 m | < 100 m | < 100 m | < 100 m |
| Group 3 fish | $SEL_{cum}$ (static) | 186 | 160 m | < 100 m | 460m | < 100 m |
| | $SEL_{cum}$ (fleeing) | 186 | < 100 m | < 100 m | < 100 m | < 100 m |

*dB re 1 μPA Sound Exposure Level (SEL)/dB re 1 μPA2 Sound Exposure Level (SEL)

6.11.230 To summarise, the underwater noise modelling for sheet piling scenarios show that noise levels and ranges for potential impacts will be greater during high tide conditions. When considering the piling of a single sheet pile, the maximum TTS ranges (186 dB $SEL_{cum}$ threshold) are predicted to occur up to 160 m from the source when considering a stationary receptor (such as spawning herring, or sandeel) during the MHWS scenario, reducing to less than 100 m when a fleeing animal is assumed. When considering eight sequentially installed sheet piles, the maximum ranges increase to a maximum of 460 m for a stationary receptor during the MHWS scenario. However, it is an overly conservative case to consider that the eight sequentially installed piles will all occur at high tide as the tide will change throughout the day.

## SENSITIVITY

6.11.231 The sensitivities of fish and shellfish VERs to underwater noise are summarised in Table 6.20, Table 6.21 and Table 6.22. The species of highest sensitivity are spawning herring (**medium** sensitivity to underwater noise), and seahorse (**high** sensitivity to underwater noise). All other VERs are of **low** to **medium** sensitivity to underwater noise.

## MAGNITUDE OF IMPACT

6.11.232 The largest impact ranges for sheet piling result from the sequential piling of eight sheet piles in MHWS, using a hammer energy of 300kJ. The maximum predicted range of impact would occur from TTS, up to 460m from the activity for stationary receptors (186 dB $SEL_{cum}$ threshold). Any injurious (mortality or potential mortal injury or recoverable injury) effects on stationary and fleeing receptors of all receptor groups are anticipated to occur within the immediate vicinity of the piling activity (<100m from the source).

6.11.233 As shown in Figure 6.21, there is no spatial overlap of the noise contours with the Downs or the Blackwater herring spawning grounds, from piling at the landfall, therefore, the magnitude of impact on spawning herring is considered to be **negligible**.

6.11.234 Whilst there is the potential for seahorse to be present, VE does not lie within an area of specific importance for the species. Nevertheless, there is the potential for seahorse to be present in the nearshore during summer, which could feasibly result in seahorse being present in the general area of the VE landfall. Whilst interaction with individual seahorses cannot be ruled out, the overall risk of interaction is considered to be low, and spatially discrete, due to the low number of records of the species across the region. It is therefore considered that the risk of one or more of these individuals being located within the impact ranges from sheet piling at the time of active piling is very small (Pierri *et al.*, 2022). Therefore, taking into consideration, the limited temporal and spatial impact from the sheet piling operations in the landfall and the low numbers of seahorse identified in the region. The magnitude of the impact that construction activities relating to the VE will have on seahorse is considered **negligible**.

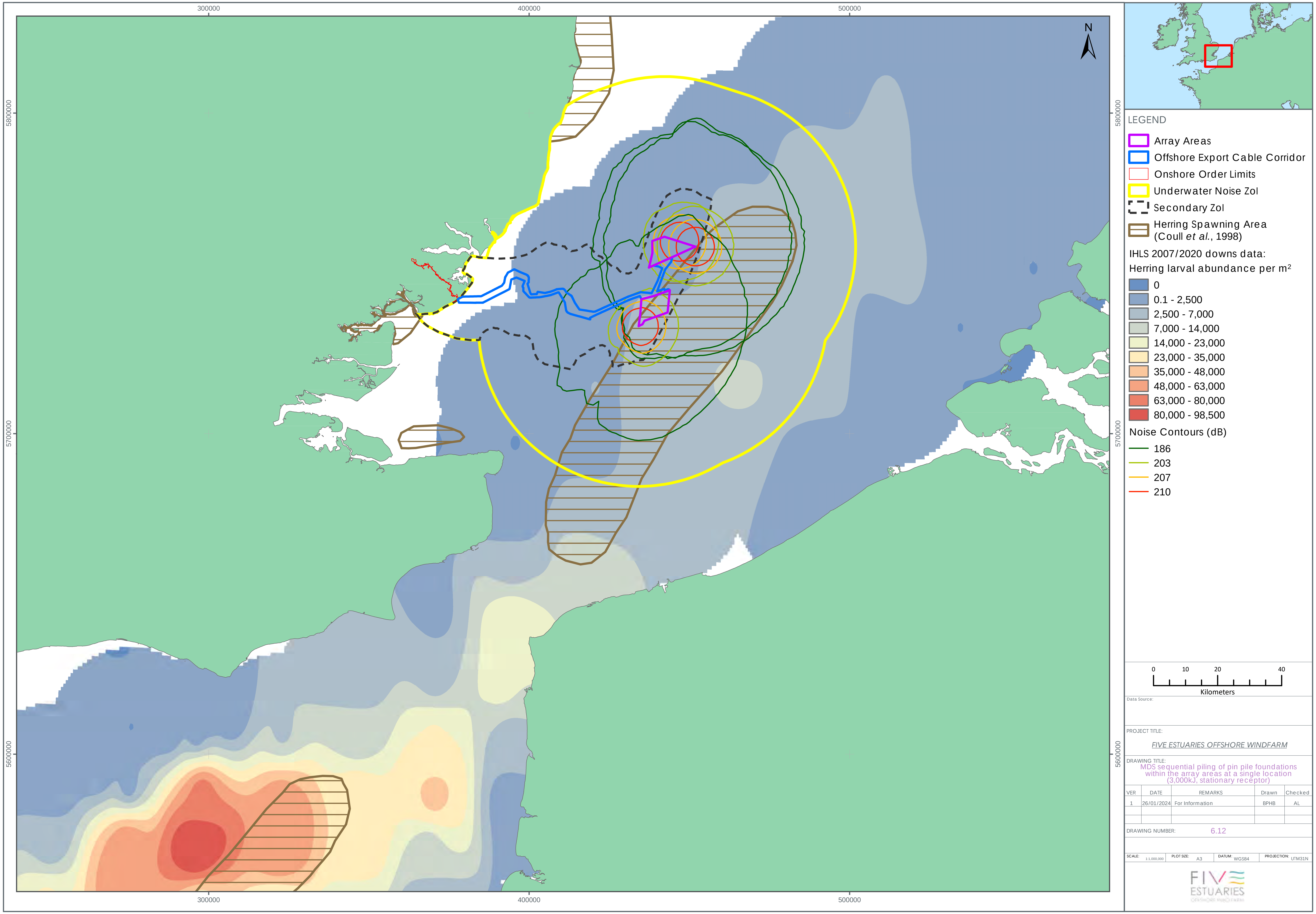
6.11.235 Considering the localised impact ranges from sheet piling in the nearshore, and the broadscale nature of all other receptor spawning grounds and distribution, the magnitude of impact on all other fish and shellfish VERs is considered to be **negligible**.

### SIGNIFICANCE OF EFFECT

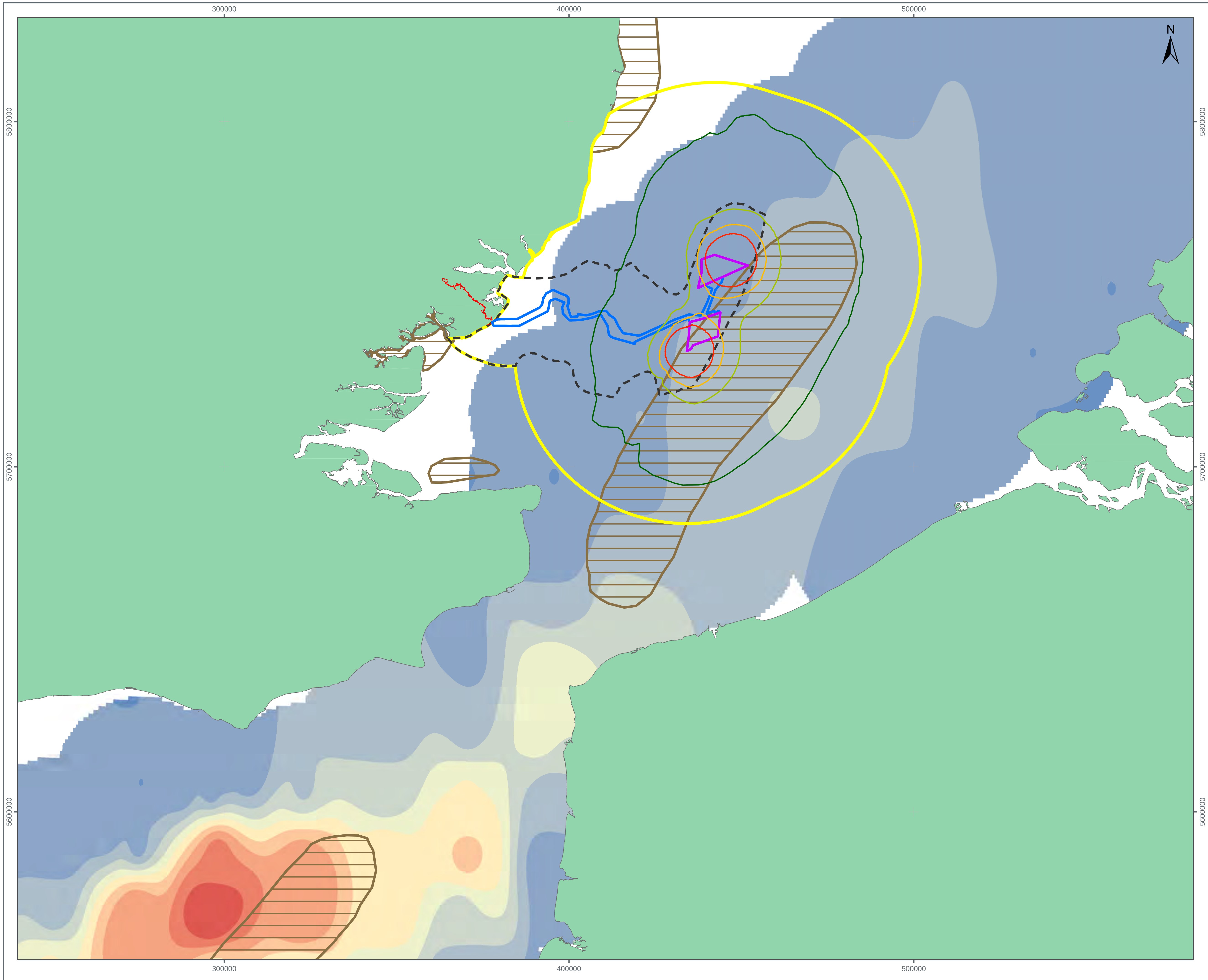
6.11.236 The maximum magnitude of impact on fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **high** (seahorse). The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

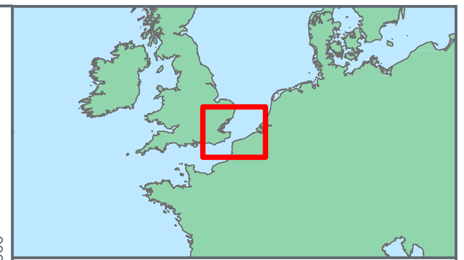
### OVERALL SIGNIFICANCE OF EFFECTS ON MORTALITY AND POTENTIAL MORTAL INJURY, RECOVERABLE INJURY, AND TTS ON FISH AND SHELLFISH RECEPTORS

6.11.237 When considering the combined effects of mortality and potential mortal injury, recoverable injury, TTS and behavioural impacts, the effects from underwater noise on fish and shellfish receptors are considered to be of **minor adverse** significance, which is not significant in EIA terms.



N
300000
400000
500000
5800000
5700000
5600000
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Order Limits
Underwater Noise ZoI
Secondary ZoI
Herring Spawning Area (Coull et al., 1998)
IHLS 2007/2020 downs data:
Herring larval abundance per m²
0
0.1 - 2,500
2,500 - 7,000
7,000 - 14,000
14,000 - 23,000
23,000 - 35,000
35,000 - 48,000
48,000 - 63,000
63,000 - 80,000
80,000 - 98,500
Noise Contours (dB)
186
203
207
210
0
10
20
40
Kilometers
Data Source:
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
MDS sequential piling of pin pile foundations within the array areas at a single location (3,000kJ, stationary receptor)
VER | DATE | REMARKS | Drawn | Checked
1 | 26/01/2024 | For Information | BPHB | AL
DRAWING NUMBER: 6.12
SCALE: 1:1,000,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Herring Spawning Area (Coull *et al.*, 1998)

IHLS 2007/2020 downs data:
Herring larval abundance per m²

- 0
- 0.1 - 2,500
- 2,500 - 7,000
- 7,000 - 14,000
- 14,000 - 23,000
- 23,000 - 35,000
- 35,000 - 48,000
- 48,000 - 63,000
- 63,000 - 80,000
- 80,000 - 98,500

Noise Contours (dB)

- 186
- 203
- 207
- 210

0 10 20 40
Kilometers

Data Source:

PROJECT TITLE:

*FIVE ESTUARIES OFFSHORE WINDFARM*

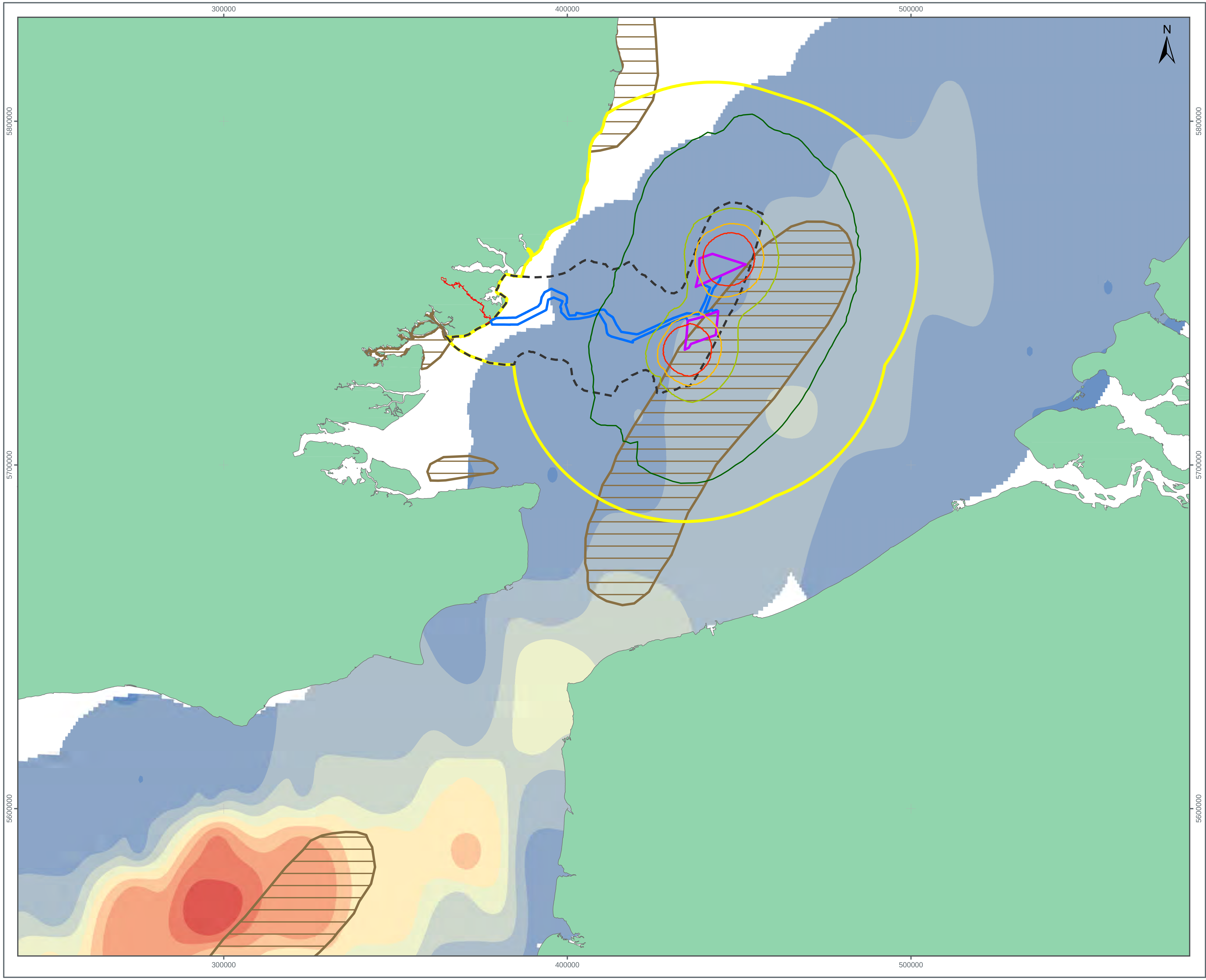
DRAWING TITLE:
MDS alternate piling of monopile foundations within the array areas at multiple locations (7,000 kJ, stationary receptors)

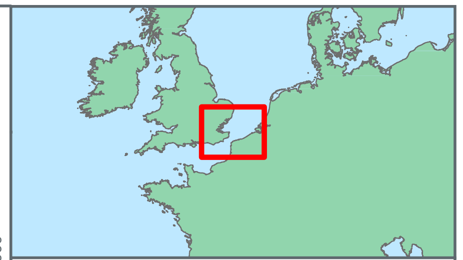
| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.13

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|

FIVE ESTUARIES OFFSHORE WINDFARM



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Herring Spawning Area (Coull *et al.*, 1998)

IHLS 2007/2020 downs data:
Herring larval abundance per m²

- 0
- 0.1 - 2,500
- 2,500 - 7,000
- 7,000 - 14,000
- 14,000 - 23,000
- 23,000 - 35,000
- 35,000 - 48,000
- 48,000 - 63,000
- 63,000 - 80,000
- 80,000 - 98,500

Noise Contours (dB)

- 186
- 203
- 207
- 210

0 10 20 40
Kilometers

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

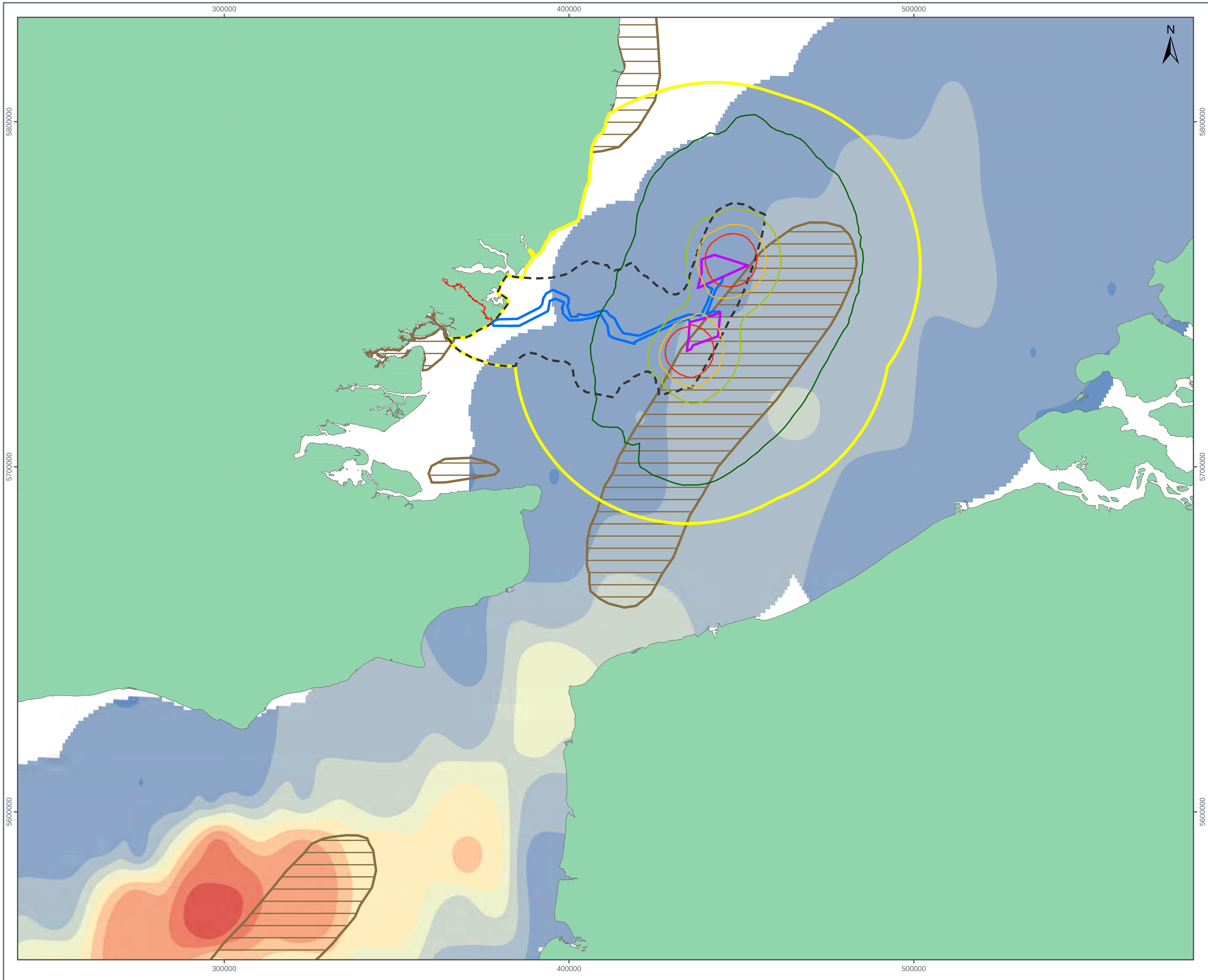
DRAWING TITLE:
MDS alternate piling of monopile foundations within the array areas at multiple locations (7,000 kJ, stationary receptors) within a 24 hour period

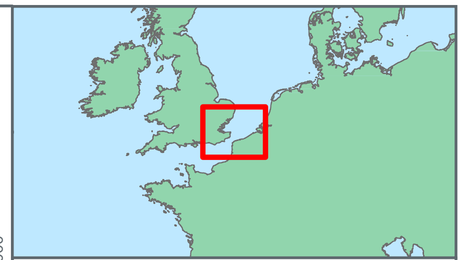
| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.14

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|

FIVE ESTUARIES OFFSHORE WINDFARM



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Herring Spawning Area (Coull *et al.*, 1998)

IHLS 2007/2020 downs data:
Herring larval abundance per $m^2$

- 0
- 0.1 - 2,500
- 2,500 - 7,000
- 7,000 - 14,000
- 14,000 - 23,000
- 23,000 - 35,000
- 35,000 - 48,000
- 48,000 - 63,000
- 63,000 - 80,000
- 80,000 - 98,500

Noise Contours (dB)

- 186
- 203
- 207
- 210

0 10 20 40
Kilometers

Data Source:

PROJECT TITLE:

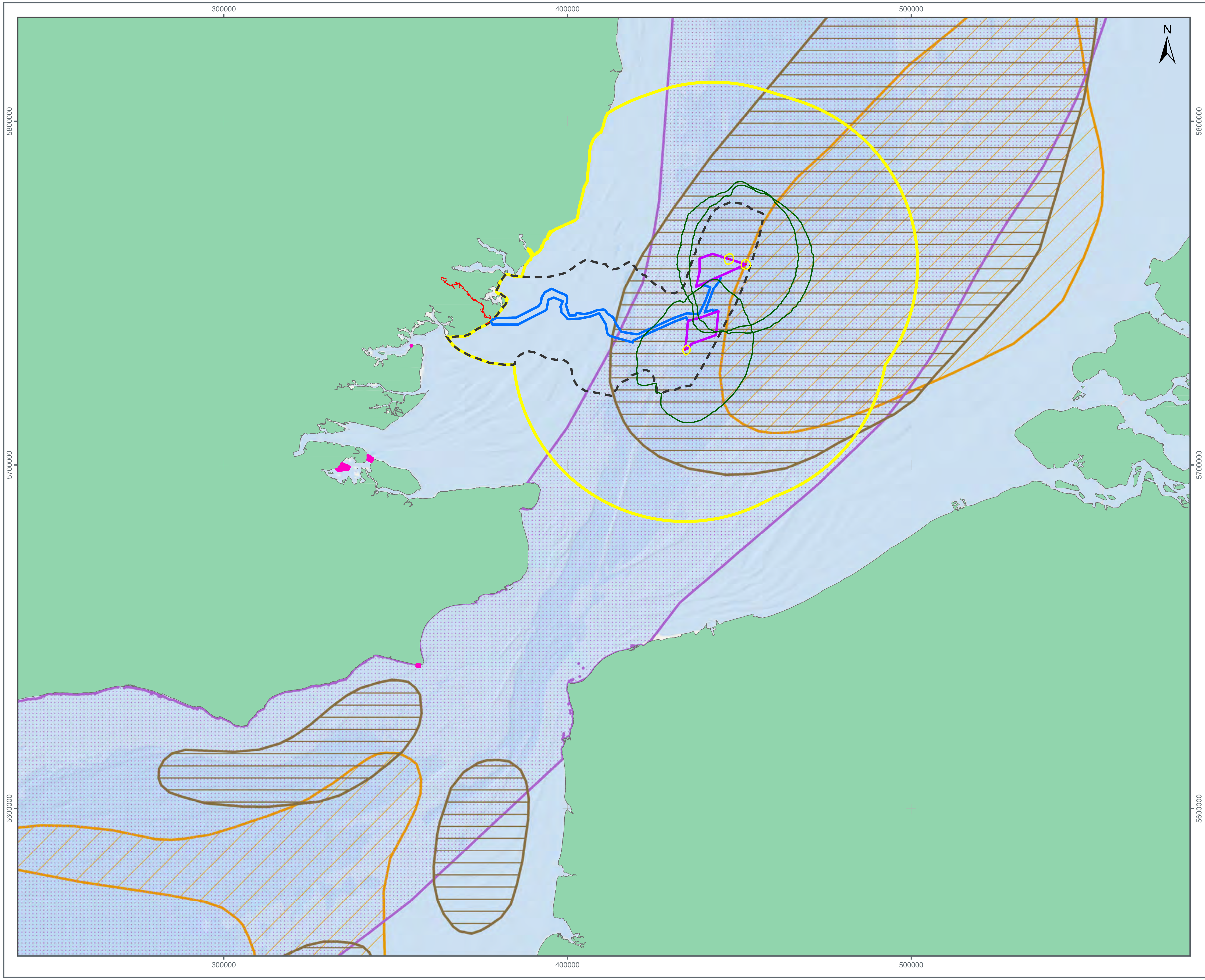
*FIVE ESTUARIES OFFSHORE WINDFARM*

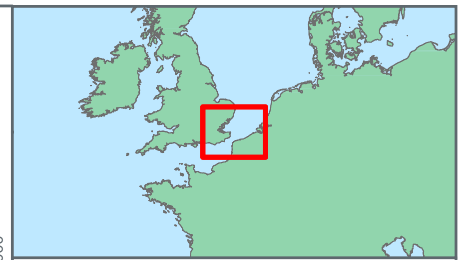
DRAWING TITLE:
MDS concurrent piling of monopile foundations at multiple locations within the array areas (7,000 kJ, stationary receptors)

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.15

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Sea Bass Nursery Grounds (Cefas, 1999)

Spawning Grounds (Coull *et al.* 1998)

- Cod
- Sprat
- Whiting

Noise Contours (dB)

- 186
- 203
- 207

0 10 20 40
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

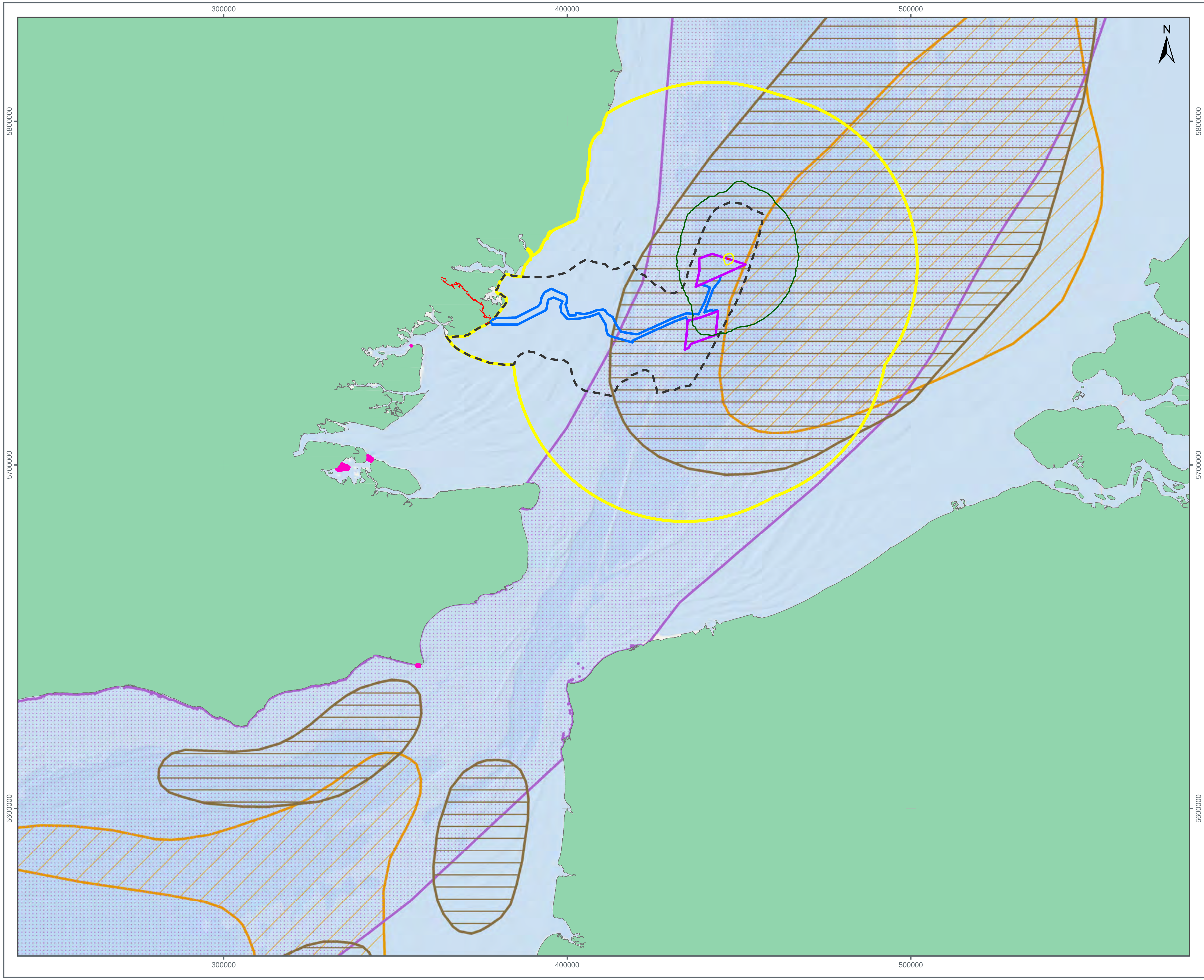
DRAWING TITLE:

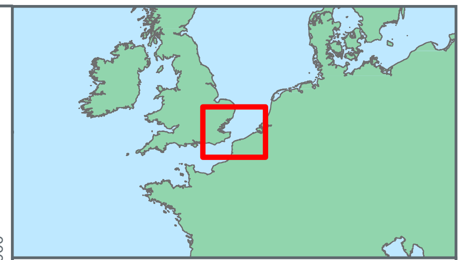
MDS piling of a single monopile foundation at one location within the array areas (7,000 kJ, fleeing receptors)

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |

DRAWING NUMBER: 6.16

| SCALE: | PLOT SIZE: | DATUM: | PROJECTION: |
|---|---|---|---|
| 1:1,000,000 | A3 | WGS84 | UTM31N |



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Sea Bass Nursery Grounds (Cefas, 1999)

Spawning Grounds (Coull *et al.* 1998)

- Cod
- Sprat
- Whiting

Noise Contours (dB)

- 186
- 203
- 207

0 10 20 40
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

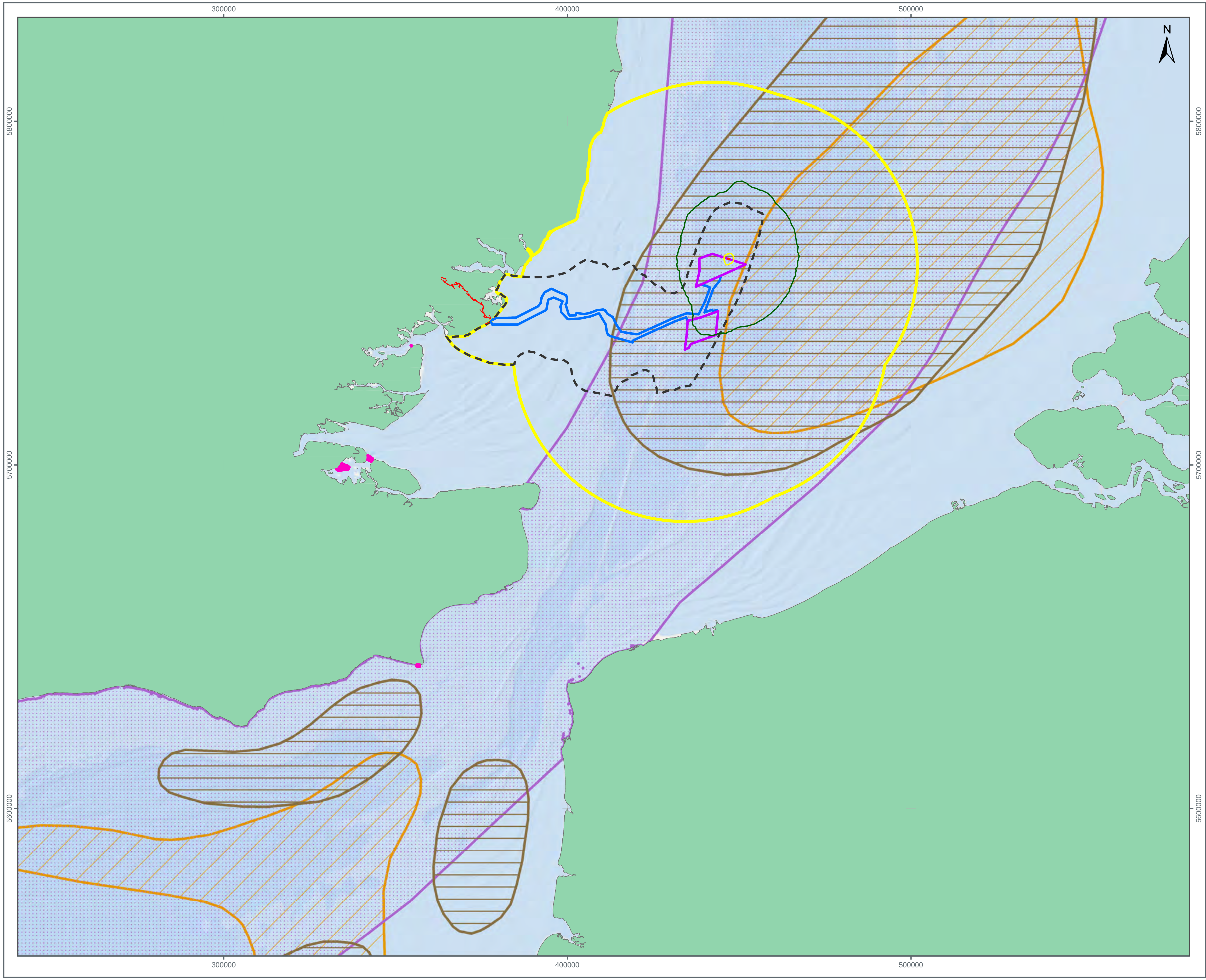
*FIVE ESTUARIES OFFSHORE WINDFARM*

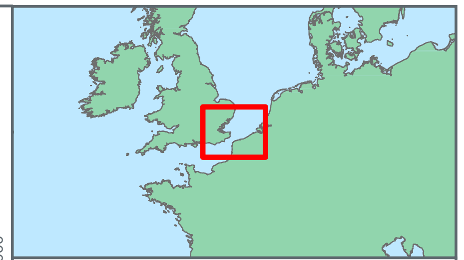
DRAWING TITLE:
MDS alternate piling of monopiles at multiple locations within the array areas (7,000kJ, fleeing receptor)

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.17

SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Sea Bass Nursery Grounds (Cefas, 1999)

Spawning Grounds (Coull *et al.* 1998)

- Cod
- Sprat
- Whiting

Noise Contours (dB)

- 186
- 203
- 207

0 10 20 40
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

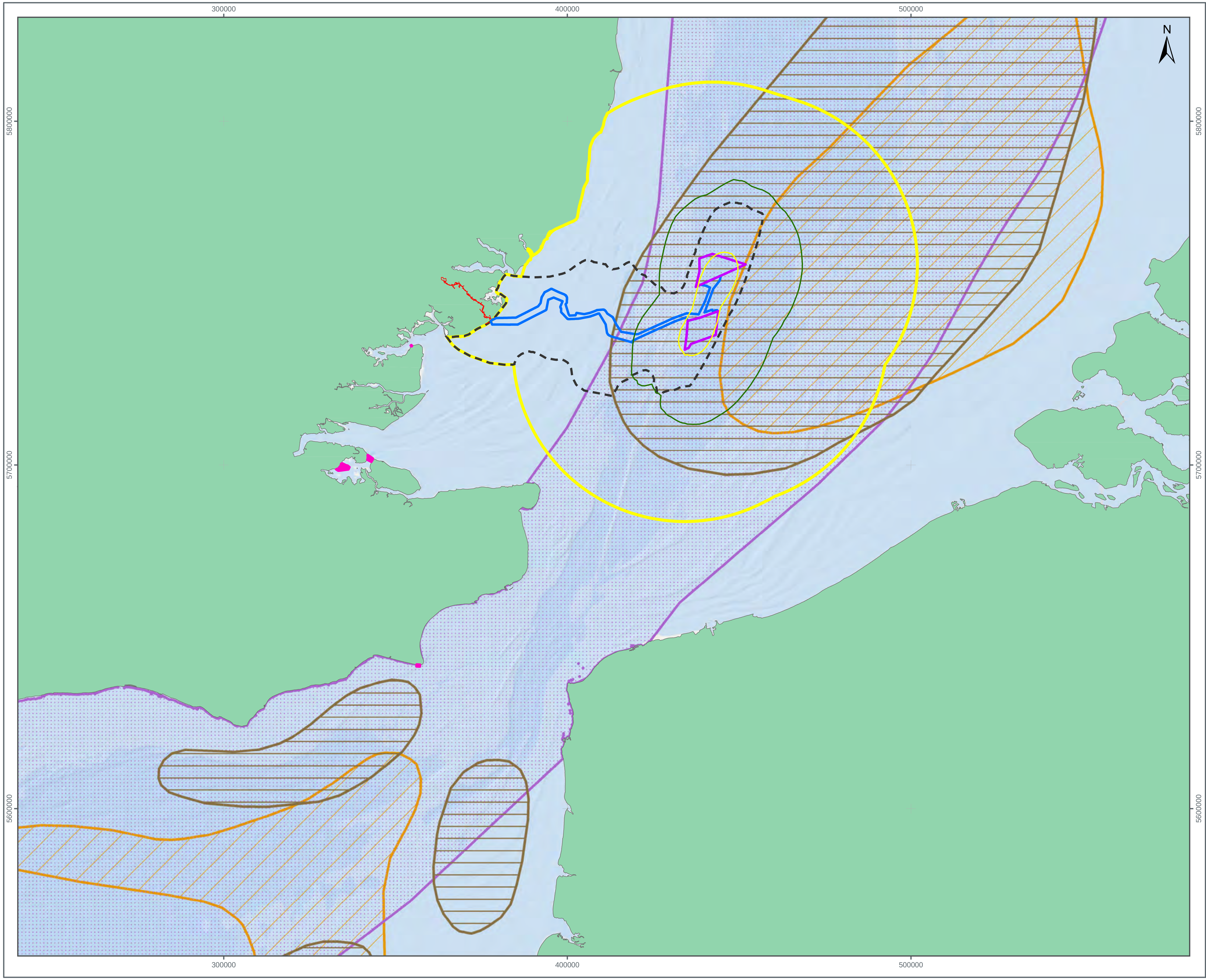
*FIVE ESTUARIES OFFSHORE WINDFARM*

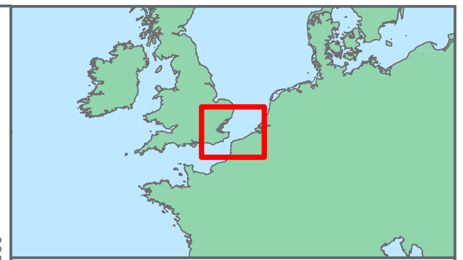
DRAWING TITLE:
MDS alternate piling of monopiles at multiple locations within the array areas (7,000kJ, fleeing receptor) within a 24 hour period

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.18

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Sea Bass Nursery Grounds (Cefas, 1999)

Spawning Grounds (Coull *et al.* 1998)

- Cod
- Sprat
- Whiting

Noise Contours (dB)

- 186
- 203

0 10 20 40
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

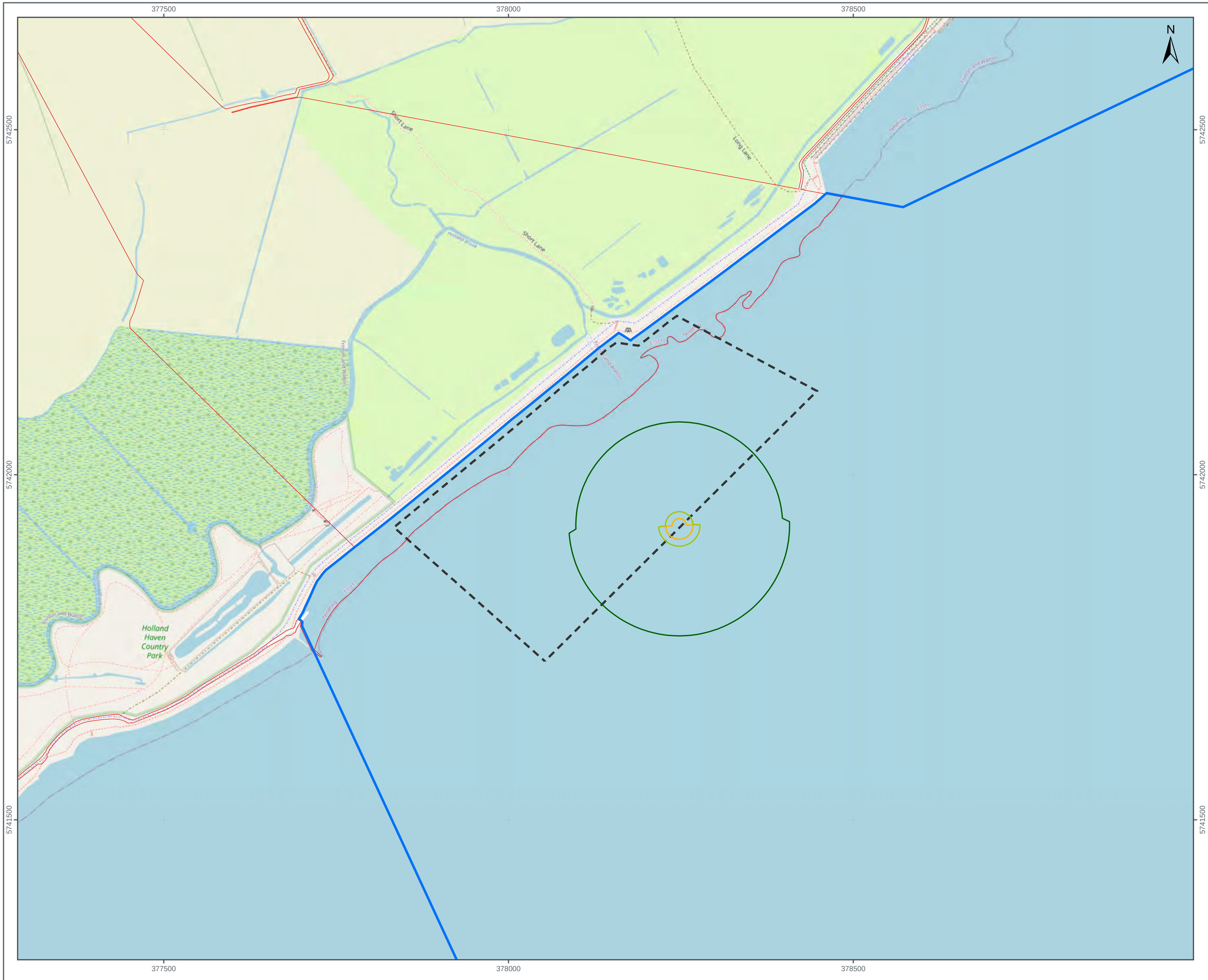
*FIVE ESTUARIES OFFSHORE WINDFARM*

DRAWING TITLE:
MDS concurrent piling of monopile foundations at multiple locations within the array areas (7,000kJ, fleeing receptor)

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.19

SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N




LEGEND

- Offshore Export Cable Corridor
- Onshore Order Limits
- Indicative Landfall HDD Exit Pit Sheet Piled Enclosure Location

Noise Contours (dB)

- 186
- 203
- 207
- 210

0 50 100 200
Meters

Data Source:
© OpenStreetMap (and) contributors, CC-BY-SA

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

MDS sequential piling of sheet piles within the landfall (300 kJ, stationary receptors)

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 18/03/2024 | For Information | BPHB | AL |

DRAWING NUMBER: 6.20

SCALE: 1:5,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES



LEGEND

- Offshore Export Cable Corridor
- Onshore Order Limits
- Indicative Landfall HDD Exit Pit Sheet Piled Enclosure Location

Noise Contours (dB)

- 186

0 50 100 200
Meters

Data Source:
© OpenStreetMap (and) contributors, CC-BY-SA

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

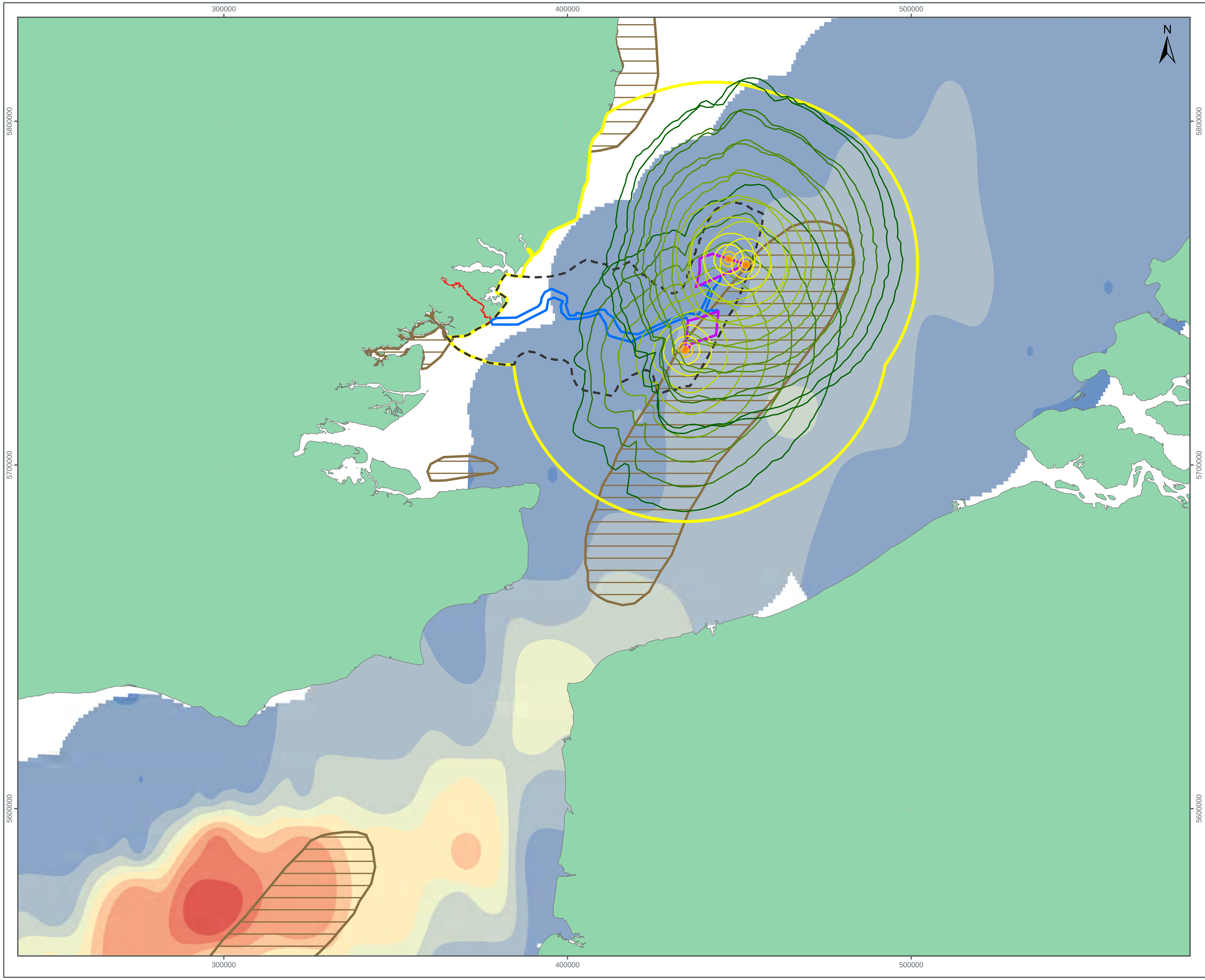
MDS sequential piling of sheet piles within the landfall (300 kJ, fleeing receptors)

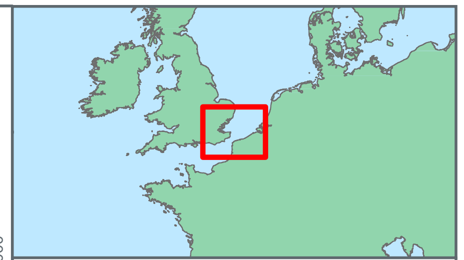
| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 18/03/2024 | For Information | BPHB | AL |

DRAWING NUMBER: 6.21

| SCALE: | PLOT SIZE: | DATUM: | PROJECTION: |
|---|---|---|---|
| 1:5,000 | A3 | WGS84 | UTM31N |

FIVE ESTUARIES



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Herring Spawning Area (Coull *et al.*, 1998)

IHLS 2007/2020 downs data:
Herring larval abundance per m²

- 0
- 0.1 - 2,500
- 2,500 - 7,000
- 7,000 - 14,000
- 14,000 - 23,000
- 23,000 - 35,000
- 35,000 - 48,000
- 48,000 - 63,000
- 63,000 - 80,000
- 80,000 - 98,500

Noise Contours (dB)

- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170
- 175
- 180
- 185
- 190
- 195
- 200

0 10,000 20,000 40,000
Meters

Data Source:

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

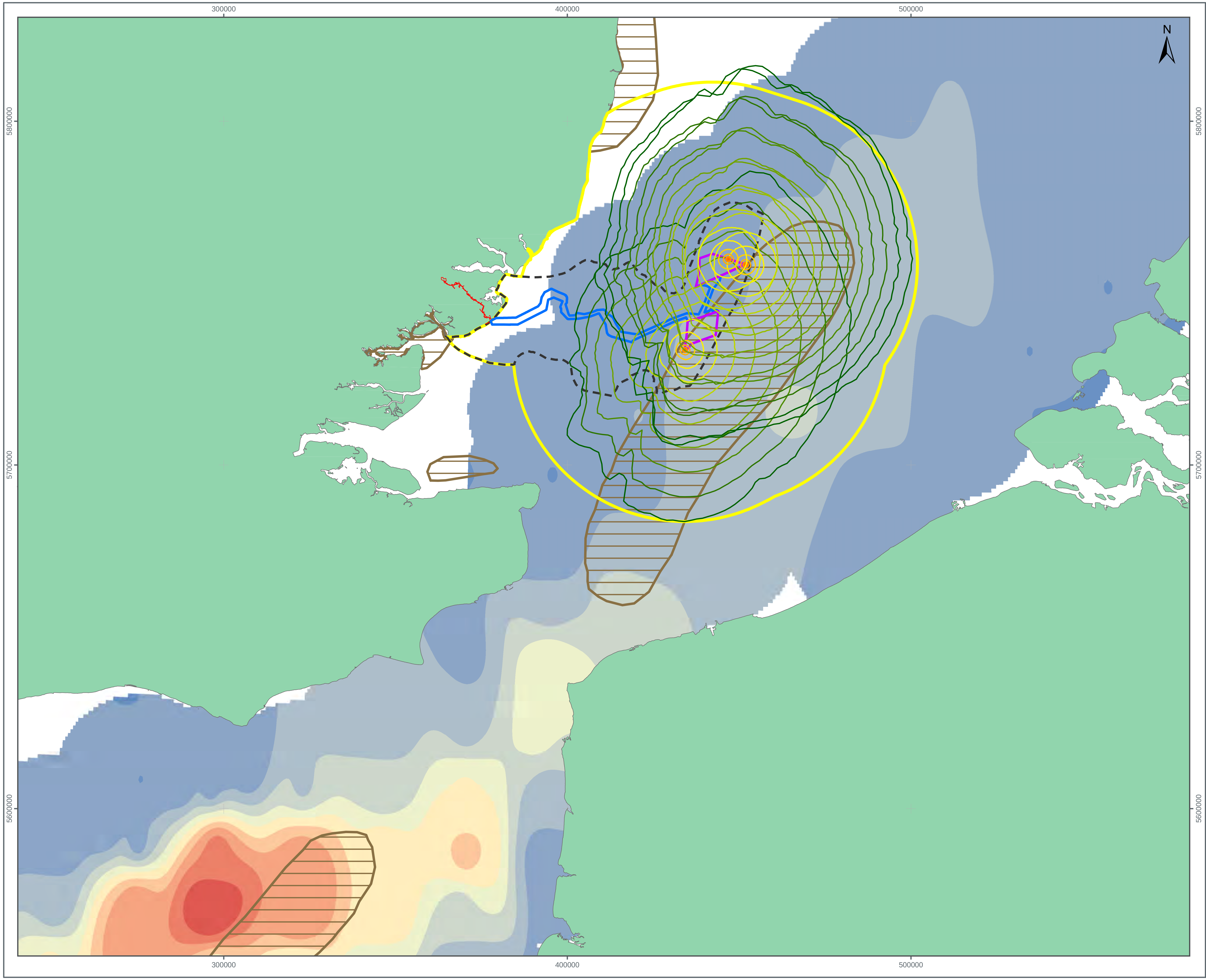
MDS piling of pin pile foundations, 5db increments (3,000 kJ, stationary receptors)

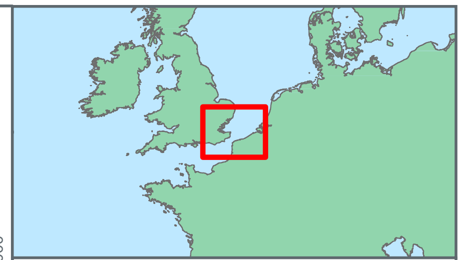
| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.22

SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES OFFSHORE WINDFARM



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Underwater Noise ZoI
- Secondary ZoI
- Herring Spawning Area (Coull *et al.*, 1998)

IHLS 2007/2020 downs data:
Herring larval abundance per m²

- 0
- 0.1 - 2,500
- 2,500 - 7,000
- 7,000 - 14,000
- 14,000 - 23,000
- 23,000 - 35,000
- 35,000 - 48,000
- 48,000 - 63,000
- 63,000 - 80,000
- 80,000 - 98,500

Noise Contours (dB)

- 186
- 203
- 207
- 210

0 10,000 20,000 40,000
Meters

Data Source:

PROJECT TITLE:
*FIVE ESTUARIES OFFSHORE WINDFARM*

DRAWING TITLE:
MDS piling of monopile foundations, 5db increments (7,000 kJ, stationary receptors)

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AL |
| | | | | |
| | | | | |

DRAWING NUMBER: 6.23

| SCALE: 1:1,000,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N |
|---|---|---|---|

FIVE ESTUARIES OFFSHORE WINDFARM

## IMPACT 2: TEMPORARY INCREASE IN SSC AND SEDIMENT DEPOSITION

6.11.238 Temporary localised increases in SSC and associated sediment deposition and smothering are expected from foundation and cable installation works (including HDD installation) and seabed preparation works (including sandwave clearance). This assessment should be read in conjunction with Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report, which provide the detailed offshore physical environment assessment (including project specific modelling of sediment plumes)

### ARRAY AREA IMPACTS

#### MAGNITUDE OF IMPACT

6.11.239 In the array areas temporary localised increases in SSC and associated sediment deposition and smothering are expected from foundation and cable installation works and seabed preparation works (including sandwave clearance).

6.11.240 Background surface SSCs across the array areas are known to vary seasonally, with summer SSC ranging from 1-3 mg/l in the arrays, increasing to 10-20 mg/l during winter months. Higher SSCs are anticipated during spring tides and storm conditions, with greatest concentrations close to the seabed (Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report).

6.11.241 Seabed preparation for foundations, sandwave clearance for cable installation, cable trenching, drilling for foundations and spoil disposal are all predicted to result in sediment plumes and localised increases in SSC. Table 6.10 presents the MDS associated with increases in SSC and deposition. Site-specific modelling of sediment plumes and deposition from seabed preparation and installation activities has been undertaken to quantify the potential footprint of the plumes, their longevity and the concentration of SSC as well as the subsequent deposition of plume material on the seabed.

6.11.242 In summary, sediment plumes caused by seabed preparation and construction activities are expected to be restricted to within a single tidal excursion from the point of release, which is captured by the fish and shellfish ecology study area (Section 6.4). Sediment plumes are expected to quickly dissipate after cessation of the construction activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels (i.e., within a couple of tidal cycles). Sediment deposition will consist primarily of coarser sediments deposited close to the source (a few hundred meters), with a small proportion of silt deposition (reducing exponentially from source).

6.11.243 PSA of the sediments sampled across the VE study area determined that sediment type varied spatially throughout the array areas; sediments in the northern array were heterogeneous with increased gravel and fines in the west of the northern array, whereas sediments across the southern array were more homogenous with coarse sand prevalent. Figure 4.3 within Volume 6, Part 5, Annex

5.1: Main Array–- Benthic Ecology Monitoring Report presents the spatial variations of percentage of sand, gravel and fines within the array areas and offshore ECC.

6.11.244 Figure 2 within Volume 6, Part 5, Annex 2.3: Physical Processes Technical Assessment, provides a useful schematic summarising the spatial extent of the impact zones associated with SSC and deposition in relation to VE. The figure details that the results of modelling can be summarised broadly in terms of three main zones of effect, based on the distance from the activity causing sediment disturbance:

- 0 to 50 m – zone of highest SSC increase and greatest likely thickness of deposition. All gravel sized sediment likely deposited in this zone, also a large proportion of sands that are not resuspended high into the water column, and also most or all dredge spoil in the active phase. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released and the manner in which the deposit settles;
  - At the time of active disturbance–- very high SSC increase (tens to hundreds of thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance; sands and gravels may deposit in local thicknesses of tens of centimetres to several metres; fine sediment is unlikely to deposit in measurable thickness; and
  - More than one hour after the end of active disturbance–- no change to SSC; no measurable ongoing deposition.
- 50 to 500 m – zone of measurable SSC increase and measurable but lesser thickness of deposition. Mainly sands that are released or resuspended higher in the water column and resettling to the seabed whilst being advected by ambient tidal currents. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released, the height of resuspension or release above the seabed, and the ambient current speed and direction at the time;
  - at the time of active disturbance–- high SSC increase (hundreds to low thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance; sands and gravels may deposit in local thicknesses of up to tens of centimetres; fine sediment is unlikely to deposit in measurable thickness.
  - more than one hour after end of active disturbance–- no change to SSC; no measurable ongoing deposition.
- 500m to the tidal excursion buffer distance – zone of lesser but measurable SSC increase and no measurable thickness of deposition. Mainly fines that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents. Plume dimensions and SSC are primarily controlled by the volume of sediment released, the patterns of current speed and direction at the place and time of release and where the plume moves to over the following 24 hours.
  - at the time of active disturbance–- low to intermediate SSC increase (tens to low hundreds of mg/l) as a result of any remaining fines in suspension, only within a narrow plume (tens to a few hundreds of metres wide), SSC decreasing

rapidly by dispersion to ambient values within one day after the end of active disturbance; fine sediment is unlikely to deposit in measurable thickness.

- one to six hours after end of active disturbance–- decreasing to low SSC increase (tens of mg/l); fine sediment is unlikely to deposit in measurable thickness.
- six to 24 hours after end of active disturbance–- decreasing gradually through dispersion to background SSC (no measurable local increase); fine sediment is unlikely to deposit in measurable thickness. No measurable change from baseline SSC after 24 to 48 hours following cessation of activities.

- Beyond the tidal excursion buffer distance or anywhere not tidally aligned to the active sediment disturbance activity–- there is no expected impact or change to SSC nor a measurable sediment deposition.

6.11.245 Further information on sediment plume distances and modelling are provided in Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes, Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report.

6.11.246 Taking the above into consideration, it can be concluded that there will be a quick dissipation of the sediment plume and a localised nature (0-50 m) of deposition impacts where smothering effects on fish and shellfish receptors might be observed.

6.11.247 The VE southern array area overlaps with a Downs stock herring spawning ground (as defined by Coull et al., 1998). A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium to high confidence that the seabed may be suitable for spawning. Taking into account the overlap of the southern array area with a Downs stock herring spawning ground (as defined by Coull et al., 1998), and the short-term, localised and intermittent nature of the works, the magnitude of impact from increased SSC and smothering from sediment deposition on spawning herring is considered to be of **medium** magnitude.

6.11.248 Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' habitats (as determined by sand content (Latto et al., 2013)) are located across the VE array areas. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the array areas as having medium to high confidence that the seabed may be suitable for spawning. However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. This is supported by the heatmapping exercise, which classified the southern North Sea, and eastern English Channel as having medium to high confidence that the seabed may be suitable for spawning. Taking into account the broadscale nature of sandeel habitats and spawning grounds across the southern North Sea, and the short-term, localised and intermittent nature of the works, the magnitude of impact from increased SSC and smothering from sediment deposition on sandeel is considered to be of **low** magnitude.

6.11.249 The impact of increased SSC and smothering from sediment deposition from construction activities is expected to be short-term, intermittent and of localised extent and reversible. The magnitude of the impact on all other fish and shellfish receptors is therefore considered to be **low**.

### SENITIVITY OF THE RECEPTORS

6.11.250 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.27 below. The fish and shellfish communities within the array areas are typical of the wider southern North Sea where relatively high levels of SSC occur naturally. Consequently, communities are exposed to and tolerant of variations in SSC and some degree of sediment deposition.

**Table 6.27: VERs Sensitivity to increased SSC and deposition**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | The secondary effects of increased concentrations of SSC in the water column and smothering (from deposition of particles as a result of comparable activities such as dredging and screening of cargo), have been shown to be inconsequential to sandeel species (MarineSpace Ltd, 2010). Sandeel eggs are also likely tolerant to increases in SSC and smothering from sediment deposition, due to the nature of resuspension and deposition within their natural high energy environment. Sandeel are deemed to be of low vulnerability, medium recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>Impacts from increased SSC and sediment deposition are of greatest concern for herring eggs as smothering of the eggs may disrupt the development of the larvae, through either the sediment grains retarding growth or through the reduction in oxygen availability around the eggs. Adult herring are mobile and as such would be expected to avoid unfavourable areas. Herring are considered to be of **medium** sensitivity to increases in SSC and sediment deposition from construction activity of VE. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, | Cod, common sole, lemon sole, plaice, whiting, sprat and mackerel all have spawning grounds overlapping the VE array areas. A horse mackerel spawning ground overlaps the fish and shellfish study area, lying to the south of the array areas. These receptors are pelagic spawners and do |

| VER | Sensitivity Justification |
| --- | --- |
| plaice, whiting, sprat, mackerel, horse mackerel). | not exhibit substrate dependency. Therefore, sediment deposition within these spawning grounds will not result in any potential loss of available spawning habitats.<br><br>These receptors are mobile, widely spread across the southern North Sea, and will experience exposure to naturally high variability to SSC within their natural range. The receptors are therefore considered to be broadly insensitive to sediment deposition. The sensitivity of these receptors to increases in SSC and sediment deposition from construction activity within the array areas is considered to be **low**. |
| VERs of limited mobility (shellfish). | Common cockles are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and are quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007). Therefore, taking into account their burrowing nature (and therefore tolerance for to smothering) (Tyler-Walters, 2007) and their broad distribution, common cockle are therefore considered to be able to adapt to localised and short-term SSC plumes. Common cockle are considered to be of **low** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>European lobsters are considered a key species within the area (ecologically and commercially); however, the species are not thought to exhibit a sedentary overwintering habit (as is observed in brown crab), being typically mobile and therefore considered able to move away from sources of disturbance. Berried females are likely to be more vulnerable to increased SSC and smothering impacts as the eggs carried require regular aeration. Lobster are therefore considered to be of **medium** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>Brown crab are considered to have a **high** tolerance to SSC and are reported to be insensitive to short-term increases in turbidity; however, they may avoid areas of increased SSC as they rely on visual acuity during predation (Neal and Wilson, 2008). Berried female brown crab exhibit a largely sedentary lifestyle during the overwintering period whilst brooding eggs. During this time, they are considered a stationary receptor, burying themselves into soft mud and sand, and are therefore unlikely to move away from disturbances. Berried females are considered more |

| VER | Sensitivity Justification |
|---|---|
| | vulnerable to smothering from sediment deposition, due to their sedentary nature at this time, and as the eggs carried require regular aeration. Taking this into account, brown crab are considered to be of **medium** vulnerability during the overwintering period, **high** recoverability (Neal and Wilson, 2008) and of regional importance, and therefore the sensitivity of the receptor is **low**.<br>Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Therefore, taking into account their burrowing nature and their broad distribution, common whelk are therefore considered to be able to adapt to localised and short-term SSC plumes. Common whelk are considered to be of **low** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br>All other shellfish VERs are distributed widely throughout the Southern North Sea, and experience exposure to naturally **high** variability in SSC within their natural range. As a result of this, all other VERs are considered to be of **low** sensitivity. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs). | All other identified VERs are mobile, and widespread throughout the wider Thames estuary and southern North Sea and will experience exposure to naturally **high** variability to SSC within their natural range, with no substrate dependence for spawning. Therefore, the sensitivity of all other fish species is considered to be **low**. |

### SIGNIFICANCE OF EFFECT

6.11.251 The impact of increased SSC and sediment deposition on spawning Downs herring is considered to be of **medium** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **moderate adverse**, which is significant in EIA terms. In response to this conclusion, an additional mitigation measure has been proposed (Table 6.12), whereby dredge material from the northern array area will not be disposed of within the southern array area, to ensure herring spawning substrate characteristics within the southern array area are maintained. This measure will be secured by a dML condition. Following the implementation of the proposed additional mitigation measure, the significance of the effect will be reduced to **minor adverse** which is not significant in EIA terms.

6.11.252 The impact of increased SSC and sediment deposition on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.253 The impact of increased SSC and sediment deposition on all other fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

### MAGNITUDE OF IMPACT

6.11.254 In the offshore ECC temporary localised increases in SSC and associated sediment deposition and smothering are expected from cable installation works (including HDD installation) and seabed preparation works (including sandwave clearance). This assessment should be read in conjunction with Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes, Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report and Volume 6, Part 5, Annex 2.2: Physical Processes Model Design and Validation which provide the detailed offshore physical environment assessment (including project specific spreadsheet modelling of sediment plumes).

6.11.255 SSCs are higher within the offshore ECC compared to the array areas and reach a peak close to the coast at the landfall. During winter months, mean values exceed 100 mg/l although, as for the array areas, higher values are anticipated during spring tides and storm conditions, with the greatest concentrations encountered close to the seabed.

6.11.256 Sandwave clearance for cable installation and cable trenching are all predicted to result in sediment plumes and localised increases in SSC. Table 5.12 presents the MDS associated with increases in SSC and deposition. Site-specific modelling of sediment plumes and deposition from seabed preparation and installation activities has been undertaken to quantify the potential footprint of the plumes, their longevity and the concentration of SSC as well as the subsequent deposition of plume material on the seabed.

6.11.257 In summary, sediment plumes caused by seabed preparation and construction activities are expected to be restricted to within a single tidal excursion from the point of release, which is captured by the fish and shellfish ecology study area (Figure 6.2). Sediment plumes are expected to quickly dissipate after cessation of the construction activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels (i.e., within a couple of tidal cycles). Sediment deposition will consist primarily of coarser sediments deposited close to the source (a few hundred meters), with a small proportion of silt deposition (reducing exponentially from source).

6.11.258 PSA of the sediments sampled across the VE study area determined that sediment type varied spatially throughout the ECC with the majority of the corridor being dominated by circalittoral mixed and circalittoral coarse sediments. Figure 4.6 in Volume 6, Part 5, Annex 5.2: Export Cable Route and Intertidal Benthic Ecology Monitoring Report presents the spatial variations of percentage of sand, gravel and fines within the offshore ECC.

6.11.259 A summary of the spatial extent of the impact zones associated with SSC and deposition outlining the three main zones of effect are outlined above in paragraph 6.11.244. Based on this, it is considered that in relation to construction works in the ECC, any sediment plume will disperse quickly with some smothering effects on fish and shellfish receptors potentially occurring within 50 m of construction activities. The impact of increased SSC and smothering from sediment deposition is expected to be short-term, intermittent and of localised extent and reversible. The magnitude of the impact is therefore considered to be **low**.

6.11.260 Release of bentonite (a non-toxic, natural clay mineral) during the trenchless installation technique punch out may result in a single, large plume of sediment in suspension into the water column. This will result in localised high levels of SSC within the nearshore, shallow waters. As presented in Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical processes, the majority of the plume will be advected in the direction of the ambient tidal currents. The direction of transport will depend on the state of the tide (flood or ebb) at the time of the release. It is expected that the plume would be dispersed to relatively low concentrations within hours of release and to background concentrations within a few tidal cycles. The drilling fluid typically consists of a low concentration bentonite – water mixture and it is expected that the bentonite will be diluted over time, without resulting in any notable settlement. The magnitude of the release of bentonite in the marine environment is assessed as **negligible**.

## SENITIVITY OF THE RECEPTORS

6.11.261 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.28 below. The fish and shellfish communities within the offshore ECC are typical of the wider southern North Sea where relatively high levels of SSC occur naturally. Consequently, communities are exposed to and tolerant of variations in SSC and some degree of sediment deposition.

**Table 6.28: VERs Sensitivity to increased SSC and deposition.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | Potential sandeel spawning grounds and prime and sub-prime habitats are located within the offshore ECC. However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. The maximum |

| VER | Sensitivity Justification |
| --- | --- |
| | sediment plume dispersal extends across a small area of the sandeel spawning ground (Coull *et al.*, 1998).<br><br>A sandeel spawning ground (as defined by Coull et al., 1998) and 'Preferred' and 'Marginal' habitats (on account of sand content) overlap the offshore portion of the ECC. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the nearshore portion of the ECC as having low confidence that the seabed may be suitable for spawning, due to the presence of discrete areas of 'Preferred' sandeel habitat, but the absence of a defined historic spawning ground. The offshore portion of the ECC was classified as having medium confidence that the seabed may be suitable for spawning, due to the presence of 'Marginal' habitat, and the overlap with a defined historic spawning ground (Coull *et al*., 1998). However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. This is supported by the heatmapping exercise, which classified the southern North Sea, and eastern English Channel as having high confidence that the seabed may be suitable for spawning, due to a wide distribution of 'Preferred' habitat, and a historic spawning ground (Coull *et al*.,1998).<br><br>The secondary effects of increased concentrations of SSC in the water column and smothering (from deposition of particles as a result of comparable activities such as dredging and screening of cargo), have been shown to be inconsequential to sandeel species (MarineSpace Ltd, 2010). Sandeel eggs are also likely tolerant to increases in SSC and smothering from sediment deposition, due to the nature of resuspension and deposition within their natural high energy environment. Based on the species reduced sensitivity to increased SSC and deposition, and their broadscale distribution of habitat, sandeel are deemed to be of **low** vulnerability, **medium** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>Impacts from increased SSC and sediment deposition are of greatest concern for herring eggs as smothering of the eggs may disrupt the development of the larvae, through either the sediment grains retarding growth or through the reduction in oxygen availability around the eggs. |

| VER | Sensitivity Justification |
| --- | --- |
| | The VE study area has a slight overlap with the northern extent of the Blackwater herring stock spawning ground (as defined by Coull *et al*., 1998), located approximately 12.5 km southwest of the offshore ECC at the nearest point. The maximum sediment plume dispersal extends across the eastern corner of the of the Blackwater stock herring spawning ground (Coull *et al*., 2010) from works within the offshore ECC. Classification of EMODnet broadscale seabed habitat data (EMODnet, 2021), identified the Blackwater Estuary as consisting of largely 'unsuitable' spawning substrates, with small discrete areas of 'Marginal' and 'Preferred' substrates (on account of their gravel content). A heatmapping exercise (detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.) identified the Blackwater Estuary as having low confidence that the seabed may be suitable for spawning (due to the presence of unsuitable spawning substrates). Furthermore, survey work undertaken in the area for the Thanet (Brown and May Marine, 2007; 2008) and Gunfleet Sands offshore wind farm developments identified that spawning appeared to be significantly smaller than the area defined by Coull *et al*., (1998), confined to a small shallow inshore area to the north of Herne Bay, in proximity to Studhill (Boyle and New, 2018), outside of the maximum sediment plume dispersal extent from the ECC. The area identified in the offshore windfarm surveys, aligns with a discrete area of 'Preferred' spawning substrate, and an area assigned a **medium** confidence that the seabed may be suitable for spawning (as assigned during a heatmapping exercise).<br><br>Adult herring are mobile and as such would be expected to avoid unfavourable areas.<br><br>Taking into consideration the vulnerability of herring eggs and larvae to this impact, and the location of active spawning outside of the VE study area, herring are considered to be of **medium** sensitivity to increases in SSC and sediment deposition from construction activity within the VE offshore ECC. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel). | Cod, common sole, lemon sole, plaice, whiting and sprat all have spawning grounds overlapping the VE offshore ECC. These receptors are pelagic spawners and do not exhibit substrate dependency. Therefore, sediment deposition within these spawning grounds will not result in any potential loss of available spawning habitats. |

| VER | Sensitivity Justification |
| --- | --- |
| | These receptors are mobile, widely spread across the southern North Sea, and will experience exposure to naturally high variability to SSC within their natural range. The receptors are therefore considered to be broadly insensitive to sediment deposition. The sensitivity of these receptors to increases in SSC and sediment deposition from construction activity at VE is considered to be **low**. |
| VERs of limited mobility (shellfish). | Common cockles are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007). Therefore, taking into account their burrowing nature (and therefore tolerance for to smothering) (Tyler-Walters, 2007) and their broad distribution, common cockle are therefore considered to be able to adapt to localised and short-term SSC plumes. Common cockle are considered to be of **low** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>European lobsters are considered a key species within the area (ecologically and commercially); however, the species are not thought to exhibit a sedentary overwintering habit (as is observed in brown crab), being typically mobile and therefore considered able to move away from sources of disturbance. Berried females are likely to be more vulnerable to increased SSC and smothering impacts as the eggs carried require regular aeration. Lobster are therefore considered to be of **medium** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>Brown crab are considered to have a high tolerance to SSC and are reported to be insensitive to short-term increases in turbidity; however, they may avoid areas of increased SSC as they rely on visual acuity during predation (Neal and Wilson, 2008). Berried female brown crab exhibit a largely sedentary lifestyle during the overwintering period whilst brooding eggs. During this time, they are considered a stationary receptor, burying themselves into soft mud and sand, and are therefore unlikely to move away from disturbances. Berried females are considered more vulnerable to smothering from sediment deposition, due to their sedentary nature at this time, and as the eggs carried require regular aeration. Taking this into account, brown crab are considered to be of **medium** vulnerability during the |

| VER | Sensitivity Justification |
|---|---|
| | overwintering period, **high** recoverability (Neal and Wilson, 2008) and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Therefore, taking into account their burrowing nature and their broad distribution, common whelk are therefore considered to be able to adapt to localised and short-term SSC plumes. Common whelk are considered to be of **low** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor is **low**.<br><br>Native oyster and native oyster beds are a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ, located 4 km from the VE offshore ECC (at its nearest point), and within the maximum sediment plume dispersal extent from the ECC. As detailed above, smothering and deposition impacts that are most likely to significantly impact communities will be local to the impact (within 0-50 m). Therefore, considering the distance of the MCZ from VE, there are not anticipated to be any adverse effects on native oyster as a feature of the MCZ. Native oyster are suspension feeders, feeding on phytoplankton, bacteria, particulate detritus and dissolved organic matter (DOM) (Korringa, 1952; Yonge, 1960), therefore the addition of fine sediment, would potentially increase food availability for oysters. However, small increases in sediment deposition have been found to reduce growth rates in native oyster (Grant *et al*., 1990), with smothering potentially preventing the flow of water through the oyster that permits respiration, feeding and removal of waste. In addition, native oyster are permanently fixed to the substratum and therefore would not be able to burrow up through the deposited material (Perry and Jackson, 2017). Due to their commercial and conservation value to the region, native oyster are considered to be of **medium** sensitivity to impacts from increased SSC and deposition.<br><br>All other shellfish VERs are distributed widely throughout the Southern North Sea, and experience exposure to naturally high variability in SSC within their natural range. As a result of this, all other VERs are considered to be of **low** sensitivity. |

| VER | Sensitivity Justification |
|---|---|
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs). | All other identified VERs are mobile, and widespread throughout the wider Thames estuary and southern North Sea and will experience exposure to naturally high variability to SSC within their natural range, with no substrate dependence for spawning. Therefore, the sensitivity of all other fish species is considered to be **low**. |

### SIGNIFICANCE OF THE EFFECT

6.11.262 The impact of increased SSC and sediment deposition on spawning Blackwater herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.263 The impact of increased SSC and sediment deposition on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.264 The impact of increased SSC and sediment deposition on native oyster as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.265 The impact of increased SSC and sediment deposition on all other fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.11.266 Sediment plumes arising in the array areas and offshore ECC have the potential to overlap with respect to both SSC and sediment deposition effects. If the activities causing sediment disturbance to occur at the same time (to within a few minutes or hours at the most) and in locations that are closely aligned with respect to the ambient tidal currents so that a second plume is created within the footprint of effect of another plume, the effect on SSC is locally additive in the area of overlap. Plumes that overlap subsequently through lateral diffusion are not an additive effect on SSC and will not exceed the values quoted for individual plumes.

6.11.267 If activities causing sediment disturbance occur at any time in locations that are closely aligned with respect to direction of the ambient tidal currents, the total sediment thickness deposited is locally additive in the area of overlap. It is noted that measurable thicknesses of deposition are only expected within relatively small distances (tens of metres) from the site of the activity, extending in the direction of tidal current at the time of the work. Therefore, there is a very low likelihood of a large total area of overlapping measurable local thicknesses of deposition resulting from overlapping plume effects.

### IMPACT 3: DIRECT AND INDIRECT SEABED DISTURBANCES LEADING TO THE RELEASE OF SEDIMENT CONTAMINANTS

6.11.268 Construction activities will re-suspend sediments, while in suspension, there is the potential for sediment-bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to an effect on fish and shellfish receptors.

6.11.269 A review of intertidal and subtidal sediment contamination within the VE site was undertaken in Volume 6, Part 2, Chapter 3: Marine Water and Sediment Quality based on site-specific surveys within the VE array areas and along the offshore ECC (Volume 6, Part 5, Annex 5.1: Main Array – Benthic Ecology Monitoring Report and Annex 5.2: Export Cable Route and Intertidal Benthic Ecology Monitoring Report). Within the VE array areas arsenic concentrations were above the Canadian PEL at all stations, however, regional contextualisation indicated that the concentrations of arsenic are within the range reported for the Outer Thames Estuary. All other samples collected across the VE array areas had contaminant concentrations below Cefas Action Level 1.

6.11.270 Within the VE offshore ECC arsenic and nickel concentrations were above the Cefas Action Level 1 at four stations, including two in the offshore section of the offshore ECC, one in the central section and one in the nearshore section. The concentration of cadmium was above the Cefas Action Level 1 at one station in the offshore section of the offshore ECC, whereas chromium concentration was above the Cefas Action Level 1 at one station in the central section. However, regional contextualisation of the results indicated that concentrations of arsenic, nickel, chromium and cadmium are within the range of concentrations reported for the Outer Thames Estuary. Copper was above the Canadian TEL at two stations and the remaining metals had concentrations below their respective Small Quantity Generator (SQGs). All other samples collected in the VE offshore ECC had contaminant concentrations below Cefas Action Level 1.

#### ARRAY AREAS IMPACTS

##### MAGNITUDE OF IMPACT

6.11.271 There is the potential for sediment bound contaminants, such as metals, hydrocarbons, and organic pollutants, to be released into the water column and lead to an effect on fish and shellfish receptors, as a result of construction activities and associated sediment mobilisation.

6.11.272 Contaminant surveys in the array areas are reported on in Volume 6, Part 5, Annex 5.1: Main Array - Benthic Ecology Monitoring Report.

6.11.273 Following disturbance as a result of construction activities, the majority of resuspended sediments are expected to be deposited within the immediate vicinity of the works. The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected.

6.11.274 Therefore, the magnitude of the impact is considered to be **negligibl**e, indicating that any release of sediment contamination is likely to be discernible over a very small area of the receptor, which does not threaten fish and shellfish receptors.

## SENSITIVITY OF THE RECEPTORS

6.11.275 Construction activities leading to the resuspension of sediments will have varying levels of effect dependent on the species present and pollutants involved. As sediment-bound contaminants would be expected to be dispersed quickly in the subtidal environment, the level of effect is predicted to be small.

**Table 6.29: Sensitivity of VERs to the release of sediment contaminants from works within the array areas.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | Potential sandeel spawning grounds (as defined by Coull *et al*., 1998), and 'Preferred' habitats (on account of sand content) are located across the array areas. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the array areas as having medium to high confidence that the seabed may be suitable for spawning. However, any impacts on sandeel are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. This is supported by the heatmapping exercise, which classified the southern North Sea, and eastern English Channel as having high confidence that the seabed may be suitable for spawning.<br><br>The VE southern array area overlaps an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), and discrete areas of 'Marginal' spawning substrates are located across the array areas (as determined by gravel content (Reach *et al*., 2013)). A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium to high confidence that the seabed may be suitable for spawning. However, site specific PSA and |

| VER | Sensitivity Justification |
|---|---|
| | geophysical data collected across the southern array area classifies much of the substrates as ‘unsuitable' for spawning. Any impacts on spawning herring are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. 'Preferred’ herring spawning substrates, and significantly higher densities of herring larvae (indicative of active spawning) are located to the south of the array areas, within the Dover Strait, and eastern English Channel. This is supported by the heatmapping exercise, which classifies the Dover Strait, and eastern English Channel as having medium to high confidence that the seabed may be suitable for spawning.<br><br>Due to their increased mobility, adult herring and larvae are less likely to be affected by marine pollution.<br><br>Fish eggs and larvae are, however, likely to be particularly sensitive, with potentially toxic effects of pollutants on fish eggs and larvae (Westerhagen, 1988). Effects of resuspension of sediment-bound contaminants (e.g., heavy metals and hydrocarbon pollution) on fish eggs and larvae are likely to include abnormal development, delayed hatching and reduced hatching success (Bunn *et al*., 2000). Sandeel and herring, of all life stages, are therefore deemed to be of **medium** sensitivity to the impact. |
| Pelagic spawning VERs with spawning grounds overlapping VE array areas and study area (cod, common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel). | Due to their increased mobility, adult fish are less likely to be affected by marine pollution. Fish eggs and larvae are likely to be particularly sensitive to the impact, it is on this basis, that these VERs are considered to be of **medium** sensitivity to the impact. |
| VERs of limited mobility (Shellfish). | Filter-feeding shellfish are considered to be more sensitive to marine pollution due to the recognised bioaccumulation which occurs within this group. Shellfish also display limited mobility and are therefore not anticipated to flee from the impact. These VERs are therefore considered to be of **medium** sensitivity to the impact. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs). | Due to their increased mobility, adult fish are less likely to be affected by marine pollution and are therefore not considered to be vulnerable to the release of sediment bound contaminants, and as such the sensitivity of the VERs is considered to be **low**. |

## SIGNIFICANCE OF EFFECT

6.11.276 The impact of sediment disturbance within the VE array areas leading to the resuspension of contaminants on fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

### MAGNITUDE OF THE IMPACT

6.11.277 There is the potential for sediment bound contaminants, such as metals, hydrocarbons, and organic pollutants, to be released into the water column and lead to an effect on fish and shellfish receptors in the offshore ECC, as a result of construction activities and associated sediment mobilisation.

6.11.278 Contaminant surveys in the offshore ECC are reported in Volume 6, Part 5, Annex 5.2: Export Cable Route and Intertidal Benthic Ecology Monitoring Report.

6.11.279 Following disturbance as a result of construction activities, the majority of resuspended sediments are expected to be deposited within the immediate vicinity of the works. The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected.

6.11.280 Therefore, the magnitude of the impact is considered to be **negligible**, indicating that any release of sediment contamination is likely to be discernible over a very small area of the receptor, which does not threaten fish and shellfish ecology receptors.

### SENSITIVITY OF THE RECEPTORS

**Table 6.30: Sensitivity of VERs to the release of sediment contaminants from works within the offshore ECC.**

| VER | Sensitivity Justification |
| --- | --- |
| Demersal spawning VERs (spawning herring and sandeel). | Potential sandeel spawning grounds (as defined by Coull *et al*., 1998), and 'Preferred' and 'Marginal' habitats (on account of sand content) are located across the offshore portion of the ECC. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the nearshore portion of the ECC as having low confidence that the seabed may be suitable for spawning, due to the presence of discrete areas of 'Preferred' sandeel habitat, but the absence of a defined historic spawning ground. The offshore portion of the ECC was classified as having medium confidence that the seabed may be suitable for spawning, due to the |

| VER | Sensitivity Justification |
| --- | --- |
| | presence of 'Marginal' habitat, and the overlap with a defined spawning ground (Coull *et al.*, 1998). However, any impacts on this species are expected to be relatively small in the context of the wider spawning ground across the southern North Sea, therefore spawning sandeel are not considered to be a sensitive receptors to the release of sediment contaminants from works within the offshore ECC.<br><br>The VE study area has a slight overlap with the northern extent of the Blackwater herring stock spawning ground (as defined by Coull *et al.*, 1998), located approximately 12.5 km southwest of the offshore ECC at the nearest point. Due to the localised nature of the impact, and the distance of the spawning ground from the ECC, spawning herring are not considered to be a sensitive receptors to the release of sediment contaminants from works within the offshore ECC. Blackwater herring are therefore of **negligible** sensitivity to the impact.<br><br>Fish eggs and larvae are, however, likely to be particularly sensitive, with potentially toxic effects of pollutants on fish eggs and larvae (Westerhagen, 1988). Effects of resuspension of sediment-bound contaminants (e.g., heavy metals and hydrocarbon pollution) on fish eggs and larvae are likely to include abnormal development, delayed hatching and reduced hatching success (Bunn *et al.*, 2000). Due to the direct overlap of the ECC with a sandeel spawing ground, sandeel are therefore deemed to be of **medium** sensitivity to the impact. |
| Pelagic spawning VERs with spawning grounds overlapping VE offshore ECC and study area (cod, common sole, lemon sole, plaice, whiting, sprat). | Due to their increased mobility, adult fish are less likely to be affected by marine pollution. Fish eggs and larvae are likely to be particularly sensitive to the impact, it is on this basis, that these VERs are considered to be of **medium** sensitivity to the impact. |
| VERs of limited mobility (Shellfish). | Filter-feeding shellfish are considered to be more sensitive to marine pollution due to the recognised bioaccumulation which occurs within this group. Shellfish also display limited mobility and are therefore not anticipated to flee from the impact. These VERs are therefore considered to be of **medium** sensitivity to the impact. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea | Due to their increased mobility, adult fish are less likely to be affected by marine pollution and are therefore not considered to be vulnerable to the release of sediment bound contaminants, and as such the sensitivity of the VERs is considered to be **low**. |

| VER | Sensitivity Justification |
|---|---|
| lamprey, sea trout smelt and elasmobranchs). | |

#### SIGNIFICANCE OF THE EFFECT

6.11.281 The impact of direct and indirect seabed disturbances within the offshore ECC leading to the release of sediment contaminants is considered to be of **negligible** magnitude, and the sensitivity of receptors affected is predicted to be a maximum of **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.11.282 Impacts may potentially occur within the array areas and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

## IMPACT 4: IMPACTS ON FISHING PRESSURE DUE TO DISPLACEMENT

### ARRAY AREAS IMPACTS

#### MAGNITUDE OF THE IMPACT

6.11.283 During construction, the intensity of fishing activities are likely to be reduced within the array areas due to the required safety distances around construction vessels.

6.11.284 Changes to the intensity of fishing activities during construction may result in increased fishing pressure on fish and shellfish populations out with the array areas due to the displacement of fishing effort into the surrounding area. As such, there is the potential for increased mortality of fish and shellfish receptors outside of the array areas as a result of fishing pressure displacement.

6.11.285 Receptors likely to be affected by an increase in fishing pressure outside the VE array areas include those demersal fish and shellfish species targeted by commercial fisheries occurring within VE (e.g., cockles, whelk, seabass, plaice, thornback ray, red mullet, lobster horse mackerel and sole) as key commercial species in the region. It would not be expected that any changes in fishing activities in this area (should these effects occur at all) would lead to changes in populations of these species as any increase would be very localised and any population level effects would be minimised by fisheries management measures (e.g., quotas, days at sea, etc.).

6.11.286 The impact is predicted to be of a local spatial extent (adjacent to the VE array areas) and of a short-term duration. The magnitude of impact is therefore considered to be **negligible**.

#### SENSITIVITY OF THE RECEPTORS

6.11.287 Fish and shellfish receptors in the array areas are deemed to be insensitive to this impact and are of local to national importance. The sensitivity of these receptors is therefore considered to be **low**.

### SIGNIFICANCE OF EFFECT

6.11.288 The impact of fishing activity displacement on fish and shellfish receptors in the array areas is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptors is considered to be **low**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### OFFSHORE ECC IMPACTS

#### MAGNITUDE OF THE IMPACT

6.11.289 During construction, the intensity of fishing activities are likely to be reduced due to the required safety distances around construction vessels. Disruption to fishing activity along the offshore ECC area is expected to be limited both temporally and spatially as any changes would be limited to the vicinity of the installation vessel as it moves along the route. The magnitude of impact is therefore considered to be **negligible**.

#### SENSITIVITY OF THE RECEPTORS

6.11.290 Fish and shellfish receptors in the offshore ECC are deemed to be insensitive to this impact and are of local to national importance. The sensitivity of these receptors is therefore considered to be **low**.

#### SIGNIFICANCE OF EFFECT

6.11.291 The impact of fishing activity displacement on fish and shellfish receptors in the offshore ECC is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptors is considered to be **low**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.11.292 The impacts will be localised with no additive spatial overlap between the array areas and offshore ECC.

## IMPACT 5: DIRECT DAMAGE (E.G. CRUSHING) AND DISTURBANCE TO MOBILE DEMERSAL AND PELAGIC FISH AND SHELLFISH SPECIES ARISING FROM CONSTRUCTION ACTIVITIES

### ARRAY AREA IMPACTS

6.11.293 Direct damage and disturbance in the VE array areas will be a likely occurrence from foundation seabed preparation, the use of jack-ups and anchored vessels and inter-array cable seabed preparation and installation works during the construction phase of the development. Most receptors are predicted to have some tolerance to this impact since it mirrors the sedimentary processes that they experience regularly as a result of natural processes.

## MAGNITUDE OF IMPACT

6.11.294 The maximum area of direct damage and disturbance of subtidal habitat due to construction activities within the VE array areas is described in Table 6.10, and equates to approximately 17% of the total seabed area within the VE array areas.

6.11.295 This impact has the potential to result in direct damage and disturbance to fish and shellfish receptors and their habitats within this footprint. The impact is predicted to be of local spatial extent (only affects the areas directly within the construction footprint), of short-term duration, intermittent and reversible. It is predicted that the impact will affect fish and shellfish receptors directly, through direct damage (crushing) and disturbance.

6.11.296 Due to the predicted local spatial extent, short-term duration and intermittent and reversible nature of the impact, the magnitude of the impact will be **low**.

## SENSITIVITY OF THE RECEPTOR

6.11.297 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.31 below.

**Table 6.31: Sensitivity of VERs to direct damage and disturbance.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | On account of the demersal spawning nature of spawning herring and sandeel they are considered to be vulnerable to the effects of direct damage and disturbance during the construction phase of development. Both receptors are considered most vulnerable during spawning when they are less mobile, with their eggs and larvae also considered to be unable to avoid this impact; therefore, in the case of this assessment, spawning herring and sandeel are considered stationary receptors. In addition to this, the species are both considered to be reliant on the presence of suitable spawning substrates.<br><br>The VE southern array area overlaps with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), and 'Marginal' spawning substrates are located across the array areas (as determined by gravel content (Reach et al., 2013)). A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium to high confidence that the seabed may be suitable for spawning. However, site specific PSA sampling across the southern array area classifies much of the substrates as 'unsuitable' for spawning. On a broader scale, 'Preferred' spawning substrates, and significantly higher densities of herring larvae (indicative of spawning activity) are located to |

| VER | Sensitivity Justification |
| --- | --- |
| | the south of the array areas, within the Dover Strait, and eastern English Channel. Considering the localised nature of the impact, any effects from direct disturbance are not likely to have a population level effect on herring.<br><br>Potential sandeel spawning grounds (as defined by Coull *et al*., 1998), and 'Preferred' habitats (on account of sand content) are located across the array areas. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the array areas as having high confidence that the seabed may be suitable for spawning. However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. Considering the localised nature of the impact, any effects direct disturbance are not likely to have a population level effect on sandeel.<br><br>Consequently, spawning herring and sandeel are deemed to be of **high** vulnerability to direct damage and disturbance, with **medium** recoverability (due to the temporary nature of the impact) and are considered to be of regional importance in the southern North Sea and are therefore of **medium** sensitivity to direct damage and disturbance during the construction phase. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat). | Due to the mobile nature of the other relevant fish species within the study area these species are considered to be not vulnerable to direct damage and as such the sensitivity of these species is considered to be **negligible**. |
| VERs of limited mobility (shellfish). | Typically, less mobile species (such as shellfish) are considered likely to have a greater vulnerability to direct damage and disturbance.<br><br>Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be of **high** vulnerability during the overwintering period, are considered to exhibit **high** recoverability and to be of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is **medium**.<br><br>Common cockles are broadly distributed across the southern North Sea and are found across a range of |

| VER | Sensitivity Justification |
| --- | --- |
| | habitats. They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007). Common whelk are considered to be of **high** vulnerability, **high** recoverability and of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is **medium**.<br><br>Berried female brown crab exhibit a largely sedentary lifestyle during the overwintering period; for the purposes of the assessment brown crab are therefore considered a stationary receptor and are considered unlikely to be able to move away from physical impacts to the seabed. Taking this into account, brown crab are considered to be of **medium** vulnerability particularly during the overwintering period, but with **high** recoverability (Neal and Wilson, 2008) (due to their broadscale distribution) and are considered to be of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance during the construction phase is **low**.<br><br>European lobster are not known to exhibit a sedentary overwintering habit, being typically mobile and therefore the species are considered to have a greater ability to move away from disturbances by comparison to brown crab. European lobster are therefore considered to be of **medium** vulnerability, are considered to have a **high** recoverability and to be of regional importance and are therefore considered to be of **low** sensitivity to direct damage and disturbance from construction activities.<br><br>All other shellfish VERs and their respective spawning grounds are distributed widely throughout the Southern North Sea and are not of high value to fisheries in the region. As a result of this, all other VERs are considered to be of **low** sensitivity to impacts from direct damage and disturbance. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout, smelt and elasmobranchs). | Due to the mobile nature of the other relevant fish species within the study area these species are considered to be not vulnerable to direct damage and as such the sensitivity of these species is considered to be **negligible**. |

## SIGNIFICANCE OF EFFECT

6.11.298 The impact of direct damage on spawning sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.299 The impact of direct damage on spawning Downs herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.300 The impact of direct damage and disturbance of shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.301 The impact of direct damage and disturbance of all other fish receptors is considered to be of **low** magnitude, and the sensitivity of the receptors is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### OFFSHORE ECC IMPACTS

6.11.302 Direct damage and disturbance in the VE offshore ECC will be a likely occurrence from cable seabed preparation and installation works during the construction phase of the development. Most receptors are predicted to have some tolerance to this impact since it mirrors the sedimentary processes that they experience regularly as a result of natural processes.

### MAGNITUDE OF IMPACTS

6.11.303 The maximum area of direct damage and disturbance of subtidal habitat due to construction activities within the offshore ECC is described in Table 6.10, and equates to approximately 9.7% of the total seabed area within the VE offshore ECC.

6.11.304 This impact has the potential to result in direct damage and disturbance to fish and shellfish receptors and their habitats within this footprint. The impact is predicted to be of local spatial extent (only affects the areas directly within the construction footprint), of short-term duration, intermittent and reversible. It is predicted that the impact will affect fish and shellfish receptors directly, through direct damage (crushing) and disturbance.

6.11.305 Due to the predicted local spatial extent, short-term duration and intermittent and reversible nature of the impact, the magnitude of the impact on fish and shellfish receptors will be **low**.

### SENSITIVITY OF RECEPTORS

**Table 6.32:Sensitivity of VERs to direct damage and disturbance in the offshore ECC**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | On account of the demersal spawning nature of spawning herring and sandeel they are considered to be vulnerable to the effects of direct damage and disturbance during the |

| VER | Sensitivity Justification |
| --- | --- |
| | construction phase of development. Both receptors are considered most vulnerable during spawning when they are less mobile, with their eggs and larvae also considered to be unable to avoid this impact; therefore, in the case of this assessment, spawning herring and sandeel are considered stationary receptors. In addition to this, the species are both considered to be reliant on the presence of suitable spawning substrates.<br><br>There is no direct overlap of the offshore ECC with the Blackwater herring spawning ground (located to the southwest of the offshore ECC), and therefore, due to the highly localised nature of the impact, no population level impacts are anticipated on the Blackwater spawning stock. Spawning herring from the Blackwater spawning stock are therefore considered to be of **negligible** sensitivity to direct damage and disturbance.<br><br>Potential sandeel spawning grounds (as defined by Coull *et al*., 1998), and 'Preferred' and 'Marginal' habitats (on account of sand content) are located across the offshore portion of the ECC. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the nearshore portion of the ECC as having low confidence that the seabed may be suitable for spawning, due to the presence of discrete areas of 'Preferred' sandeel habitat, but the absence of a defined historic spawning ground. The offshore portion of the ECC was classified as having medium confidence that the seabed may be suitable for spawning, due to the presence of 'Marginal' habitat, and the overlap with a defined spawning ground (Coull *et al*., 1998). However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea and eastern English Channel, where 'Preferred' habitats and spawning grounds are broadly distributed. Consequently, spawning sandeel are deemed to be of high vulnerability to direct damage and disturbance, with medium recoverability (due to the temporary nature of the impact) and are considered to be of regional importance in the southern North Sea and are therefore considered to be of **medium** sensitivity to direct damage and disturbance during the construction phase. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, | Due to the mobile nature of the other relevant fish species within the study area these species are not considered vulnerable to direct damage and as such the sensitivity of these species is considered to be **negligible**. |

| VER | Sensitivity Justification |
| --- | --- |
| common sole, lemon sole, plaice, whiting, sprat). | |
| VERs of limited mobility (shellfish). | Typically, less mobile species (such as shellfish) are considered likely to have a greater vulnerability to direct damage and disturbance.<br><br>Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be of high vulnerability during the overwintering period, are considered to exhibit high recoverability and to be of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is **medium**.<br><br>Common cockles are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and are quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007). Common whelk are considered to be of high vulnerability, high recoverability and of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is **medium**.<br><br>Native oyster and native oyster beds are a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ. There is no direct overlap of the offshore ECC with the Blackwater, Crouch, Roach and Colne Estuaries MCZ (located 4 km from the VE ECC), and therefore, due to the highly localised nature of the impact, no impacts on native oyster as a feature of the MCZ are anticipated from temporary habitat loss. Native oyster within the MCZ are therefore of **negligible** sensitivity to direct damage and disturbance.<br><br>Native oyster are broadly distributed across the southern North Sea and are of commercial value to fisheries within the region. Native oysters are permanently fixed to the substratum and therefore would not be able to flee from disturbance. Due to their commercial value and stationary nature, native oyster are considered to be of **medium** sensitivity to impacts from direct damage and disturbance.<br><br>All other shellfish VERs and their respective spawning grounds are distributed widely throughout the Southern North Sea and are not of high value to fisheries in the |

| VER | Sensitivity Justification |
|---|---|
| | region. As a result of this, all other VERs are considered to be of **low** sensitivity to impacts from direct damage and disturbance. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river ans sea lamprey, sea trout smelt and elasmobranchs). | Due to the mobile nature of the other relevant fish species within the study area these species are considered to be not vulnerable to direct damage and as such the sensitivity of these species is considered to be **negligible**. |

#### SIGNIFICANCE OF EFFECT

6.11.306 The impact of direct damage on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.307 The impact of direct damage on spawning Blackwater herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.308 The impact of direct damage on native oyster as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.309 The impact of direct damage and disturbance of all other shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.310 The impact of direct damage and disturbance of all other fish receptors is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

#### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.11.311 Impacts may potentially occur within the array areas and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

### IMPACT 6: ACCIDENTAL POLLUTION EVENTS DURING THE CONSTRUCTION PHASE RESULTING IN POTENTIAL EFFECTS ON FISH AND SHELLFISH RECEPTORS

6.11.312 Accidental spillage of chemicals and substances (e.g., grout) from vessels used in the construction phase (including vehicles and equipment in intertidal habitats) may impact on fish and shellfish, resulting in behavioural effects such as avoidance of affected areas and prevention of spawning. Chemical spills may also have sub-lethal to lethal effects dependent on the spatial and temporal extent of the exposure and the level of toxicity.

## ARRAY AREA IMPACTS

### MAGNITUDE OF IMPACT

6.11.313 The magnitude of an accidental spill will be limited by the size of chemical or oil inventory on construction vessels. In addition, released hydrocarbons will be subject to rapid dilution, weathering and dispersion and will be unlikely to persist in the marine environment. The likelihood of an incident will be reduced by the implementation of an Outline Project Environmental Management Plan (PEMP) and Outline Marine Pollution Contingency Plan (MPCP) (see Table 6.11), which will be approved by the relevant stakeholders and secured through DCO. Taking this into consideration, the magnitude of impact is therefore considered to be **low**.

### SENSITIVITY OF RECEPTOR

6.11.314 The sensitivity of the receptors will vary depending on a range of factors including species and life stage with adult fish less likely to be affected by marine pollution, due to their increased mobility, compared to fish eggs, larvae, juveniles and shellfish species. Any such pollution events will therefore have varying levels of effect dependent on the species present, and pollutants involved. However, as fuel and oil spills are likely to be dispersed on the surface, effects on fish and shellfish receptors are likely to be limited. The sensitivities of fish and shellfish receptors to marine pollution are detailed in Table 6.29, and were assessed as having a maximum sensitivity of **medium.**

### SIGNIFICANCE OF EFFECT

6.11.315 The impact of accidental pollution events on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

### MAGNITUDE OF IMPACT

6.11.316 The magnitude of an accidental spill will be limited by the size of chemical or oil inventory on construction vessels. In addition, released hydrocarbons will be subject to rapid dilution, weathering and dispersion and will be unlikely to persist in the marine environment. The likelihood of an incident will be reduced by the implementation of an Outline Project Environmental Management Plan (PEMP) and Outline Marine Pollution Contingency Plan (MPCP) (see Table 6.11), which will be approved by the relevant stakeholders and secured through DCO. Taking this into consideration, the magnitude of impact is therefore considered to be **low**.

### SENSITIVITY OF RECEPTOR

6.11.317 The sensitivity of the receptors will vary depending on a range of factors including species and life stage with adult fish less likely to be affected by marine pollution, due to their increased mobility, compared to fish eggs, larvae, juveniles and shellfish species. Any such pollution events will therefore have varying levels of effect dependent on the species present, and pollutants involved. However, as fuel and oil spills are likely to be dispersed on the surface, effects on fish and shellfish receptors are likely to be limited. The sensitivities of fish and shellfish receptors to marine pollution are detailed in Table 6.29, and were assessed as having a maximum sensitivity of **medium.**

### SIGNIFICANCE OF EFFECT

6.11.318 The impact of accidental pollution events on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.11.319 Impacts may potentially occur within the array area and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

## IMPACT 7: TEMPORARY HABITAT LOSS/DISTURBANCE FROM CONSTRUCTION OPERATIONS INCLUDING FOUNDATION INSTALLATION AND CABLE LAYING OPERATIONS

6.11.320 Temporary habitat loss and disturbance in the VE fish and shellfish study area will be a likely occurrence from foundation seabed preparation, the use of jack-ups and anchored vessels and cable seabed preparation and installation works during the construction phase of the development. These construction activities have the potential to impact on fish and shellfish ecology by the removal of essential habitats for survival (e.g., spawning, nursery and feeding habitats).

### ARRAY AREAS IMPACTS

### MAGNITUDE OF IMPACT

6.11.321 The maximum area of temporary habitat loss/disturbance due to the presence of foundations, scour protection and cable protection is presented in Table 6.10 and equates to approximately 17% of the total seabed area within the VE array areas. Comparable habitats and fish and shellfish species compositions are present and widespread within the wider area.

6.11.322 The impact is predicted to be of local spatial extent (i.e., within the POL), of short-term duration and reversible. It is predicted that the impact will affect fish and shellfish receptors directly. Taking this into account, the magnitude of impact on fish and shellfish receptors is considered to be **low**.

### SENSITIVITY OF RECEPTORS

6.11.323 The sensitivity rating assigned to each VER that characterises the array areas, and associated justification is provided in Table 6.33 below.

**Table 6.33: Sensitivity of VERs to temporary habitat loss.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | On account of the demersal spawning nature of spawning herring and sandeel they are considered to be vulnerable to the effects of temporary habitat loss during the construction phase of development. Both receptors are considered most vulnerable during spawning when they are less mobile, with their eggs and larvae also considered to be unable to avoid this impact; therefore, in the case of this assessment, spawning herring and sandeel are considered stationary receptors. In addition to this, the species are both considered to be reliant on the presence of suitable spawning substrates.<br><br>The VE southern array area overlaps with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), and 'Marginal' spawning substrates are located across the array areas (as determined by gravel content (Reach et al., 2013)). A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium to high confidence that the seabed may be suitable for spawning. However, site specific PSA and geophysical data collected across the southern array area classifies much of the substrates as 'unsuitable' for spawning. On a broader scale, 'Preferred' spawning substrates, and significantly higher densities of herring larvae (indicative of spawning activity) are located to the south of the array areas, within the Dover Strait, and eastern English Channel. Considering the localised nature of the impact, any effects direct disturbance are not likely to have a population level effect on herring.<br><br>Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' habitats (as determined by sand content) are located across the array areas. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the array areas as having high confidence that the seabed may be suitable for spawning. However, any impacts on this |

| VER | Sensitivity Justification |
|---|---|
| | species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. Considering the localised nature of the impact, and the broadscale distribution of sandeel spawning grounds and habitat, any effects of habitat loss are not likely to have a population level effect on sandeel.<br><br>Spawning herring and sandeel are deemed to be of high vulnerability to habitat loss, with **medium** recoverability (due to the temporary nature of the impact) and are considered to be of regional importance in the southern North Sea and are therefore of **medium** sensitivity to direct damage and disturbance during the construction phase. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel). | These receptors are pelagic spawners and therefore do not display substrate dependency, and therefore are not considered vulnerable to temporary habitat loss and as such the sensitivity of these species is considered to be **negligible**. |
| VERs of limited mobility (shellfish). | Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be vulnerable to temporary habitat loss during the overwintering period.<br><br>Common cockles are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and are quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007), and therefore are considered potentially sensitive to temporary habitat loss.<br><br>Brown crabs are known to be associated with rocky substrates but also inhabit mixed coarse, sand, and soft sediments (Hall *et al*., 1993). Berried female brown crab bury themselves into soft mud and sand, while brooding eggs in the overwintering period.<br><br>It should be noted however, that common whelk, common cockle and brown crab are substrate dependent rather than being philopatric and can therefore fully utilise adjacent areas which will be unaffected. Therefore, the sensitivity of these receptors is considered to be **low**. |

| VER | Sensitivity Justification |
|---|---|
| | European lobster are broadly distributed across the southern North Sea and are found across a range of habitats. Lobster are not known to exhibit substrate dependant behaviours and are therefore considered to be of **low** sensitivity to temporary habitat loss.<br>All other shellfish VERs are distributed widely throughout the Southern North Sea and are not of high value to fisheries in the region. As a result of this, all other VERs are considered to be of **low** sensitivity to impacts from temporary habitat loss. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs). | These species do not display substrate dependency, and therefore are not considered vulnerable to temporary habitat loss and as such the sensitivity of these species is considered to be **negligible**. |

### SIGNIFICANCE OF EFFECT

6.11.324 The impact of temporary habitat loss on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.325 The impact of temporary habitat loss on spawning Downs herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.326 The impact of temporary habitat loss of shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.327 The impact of temporary habitat loss of all other fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

### MAGNITUDE OF IMPACTS

6.11.328 Of the total area of temporary habitat loss described in Table 6.10, a maximum of approximately 14.7 km² will be disturbed within the subtidal areas of the offshore ECC as a result of seabed preparation, export cable installation, burial and jointing. This equates to approximately 9.7% of the total seabed area within the VE offshore ECC.

6.11.329 The impact is predicted to be of local spatial extent (i.e., within the offshore ECC), of short-term duration and reversible. It is predicted that the impact will affect fish and shellfish receptors directly. Taking this into account, the magnitude of impact on fish and shellfish receptors is considered to be **low**.

### SENITIVITY OF THE RECEPTORS

**Table 6.34: Sensitivity of VERs to temporary habitat loss within the offshore ECC**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | On account of the demersal spawning nature of spawning herring and sandeel they are considered to be vulnerable to the effects of temporary habitat loss during the construction phase of development. Both receptors are considered most vulnerable during spawning when they are less mobile, with their eggs and larvae also considered to be unable to avoid this impact; therefore, in the case of this assessment, spawning herring and sandeel are considered stationary receptors. In addition to this, the species are both considered to be reliant on the presence of suitable spawning substrates.<br><br>As stated above there is no direct overlap of the offshore ECC with the Blackwater herring spawning ground, and therefore, considering the highly localised nature of the impact, no population level impacts are anticipated on the Blackwater spawning stock. Spawning herring from the Blackwater spawning stock are therefore considered to be of **negligible** sensitivity to temporary habitat loss.<br><br>Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' and 'Marginal' habitats (on account of sand content) are located across the offshore ECC. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the nearshore portion of the ECC as having low confidence that the seabed may be suitable for spawning, due to the presence of 'Preferred' sandeel habitat, but the absence of a defined historic spawning ground. The offshore portion of the ECC was classified as having medium confidence that the seabed may be suitable for spawning, due to the presence of 'Marginal' habitat, and the overlap with a defined spawning ground (Coull et al., 1998). However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. |

| VER | Sensitivity Justification |
|---|---|
| | Consequently, spawning sandeel are deemed to be of **high** vulnerability to direct damage and disturbance, with **medium** recoverability (due to the temporary nature of the impact) and are considered to be of regional importance in the southern North Sea and are therefore considered to be of **medium** sensitivity to direct damage and disturbance during the construction phase. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat). | These receptors are pelagic spawners and therefore do not display substrate dependency, and therefore are not considered vulnerable to temporary habitat loss and as such the sensitivity of these species is considered to be **negligible**. |
| VERs of limited mobility (shellfish). | Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be vulnerable to temporary habitat loss during the overwintering period.<br><br>Common cockles are broadly distributed across the southern North Sea and are found across a range of habitats. They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and are quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007), and therefore are considered potentially sensitive to temporary habitat loss.<br><br>Native oyster and native oyster beds are a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ. As stated above, there is no direct overlap of the offshore ECC with the Blackwater, Crouch, Roach and Colne Estuaries MCZ, and therefore no impacts on native oyster as a feature of the MCZ are anticipated. Native oyster as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ are therefore considered to be of **negligible** sensitivity to temporary habitat loss.<br><br>Native oyster are broadly distributed across the southern North Sea and are of commercial value to fisheries within the region. Native oysters are permanently fixed to the substratum and therefore would not be able to flee from disturbance.<br><br>Brown crabs are known to be associated with rocky substrates but also inhabit mixed coarse, sand, and soft sediments (Hall *et al*., 1993). Berried female brown crab |

| VER | Sensitivity Justification |
|---|---|
| | bury themselves into soft mud and sand, while brooding eggs in the overwintering period.<br><br>It should be noted however, that common whelk, common cockle and brown crab are substrate dependent rather than being philopatric and can therefore fully utilise adjacent areas which will be unaffected. Therefore, the sensitivity of these receptors is considered to be **low**.<br><br>European lobster are broadly distributed across the southern North Sea and are found across a range of habitats. Lobster are not known to exhibit substrate dependant behaviours and are therefore considered to be of **low** sensitivity to temporary habitat loss.<br><br>All other shellfish VERs are distributed widely throughout the Southern North Sea and are not of high value to fisheries in the region. As a result of this, all other VERs are considered to be of **low** sensitivity to impacts from temporary habitat loss. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout, smelt and elasmobranchs). | These species do not display substrate dependency, and therefore are not considered vulnerable to temporary habitat loss and as such the sensitivity of these species is considered to be **negligible**. |

SIGNIFICANCE OF EFFECT

6.11.330 The impact of temporary habitat loss on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.331 The impact of temporary habitat loss spawning Blackwater herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.332 The impact of temporary habitat loss on native oyster as designated as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.11.333 The impact of temporary habitat loss of shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.11.334 The impact of temporary habitat loss of all other fish and shellfish receptors is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.11.335 Impacts may potentially occur within the array area and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

## 6.12 ENVIRONMENTAL ASSESSMENT: OPERATIONAL PHASE

### IMPACT 8: UNDERWATER NOISE AS A RESULT OF OPERATIONAL WTGS AND MAINTENANCE VESSEL TRAFFIC RESULTING IN POTENTIAL EFFECTS ON FISH AND SHELLFISH RECEPTORS.

6.12.1 Underwater noise levels during the operational phase are predicted to be considerably lower than those of the construction phase, being limited to noise from operational WTGs and maintenance vessel traffic.

### ARRAY AREAS IMPACTS

#### MAGNITUDE OF IMPACT

6.12.2 Underwater noise from an operational WTGs within the array areas mainly originate from the gearbox and the generator and has tonal characteristics (Madsen *et al*., 2005; Tougaard *et al*., 2009). The radiated levels are low and the spatial extent of the potential impact of the operational wind farm noise on marine receptors is generally estimated to be small and thus unlikely to result in any injury to fish (Wahlberg and Westerberg, 2005). Besides the sound source level, the potential for impact will also depend on the propagation environment, the receptor's hearing ability and the ambient sound levels.

6.12.3 Marine animals may perceive the radiated tonal components where they exist above the ambient noise levels, which may result in a behavioural response of the receptor or lead to a reduced detection of other sounds due to masking. Previous studies show that behavioural responses of fish are only likely at close ranges from the WTGs, (i.e., a few metres) (Wahlberg and Westerberg, 2005).

6.12.4 Although effects on fish are difficult to establish given the lack of information available in the scientific literature, there is indicative evidence that fish would be unlikely to show significant avoidance to the noise levels radiating from the WTGs. The ICES has formulated recommendations for maximum radiated underwater noise from research vessels which are approximately 30 dB above the hearing threshold of cod and spawning herring (ICES, 1995). The implication of this is that the presence of continuous noise that is not significantly above the hearing threshold of fish is not thought to cause any significant movement of fish away from the source. Studies of very low frequency sound have indicated that consistent deterrence from the source is only likely to occur at particle accelerations equivalent to a free-field sound pressure level of 160 dB re 1 μPa (RMS) (Sand *et al*., 2001). This is higher than the noise levels reported in the open literature for operational wind farms measured at a number of ranges, all within a few hundred metres of the WTGs (Nedwell *et al*., 2007a; Edwards *et al*., 2007; Betke *et al*., 2004, see also Wahlberg and Westerberg, 2005 and Madsen *et al*., 2006). The particle acceleration resulting from an operational wind WTGs has also been measured by Sigray *et al*. (2011) with the resultant levels being considered too low to be of concern for behavioural reactions from fish. Furthermore, the particle acceleration levels measured at 10 m from the WTGs were comparable with hearing thresholds. Whilst limited, the available data provides an indicator that operational wind WTGs are unlikely to result in disturbance of fish except within very close proximity of the WTGs structure, as postulated by Wahlberg and Westerberg (2004). However, the available measurement data is mostly for smaller WTGs (up to 1.5 MW) and it would be expected that larger wind WTGs would result in different acoustic characteristics, with foundation type also having an influence on the acoustic characteristics of the noise radiated from the structure.

6.12.5 Noise would also result from surface vessels servicing the wind farm. However, noise levels reported by Malme *et al*. (1989) and Richardson *et al*. (1995) for large surface vessels indicate that physiological damage to fish and shellfish is unlikely, although the levels could be sufficient to cause local disturbance of sensitive marine fauna (e.g., clupeids such as herring and sprat) in the immediate vicinity of the vessel, depending on ambient noise levels.

6.12.6 Considering the operational WTGs noise of the wind farm and any associated service vessels, the ambient noise levels within the site would be expected to be lower than those present in the vicinity of nearby shipping lanes.

6.12.7 The impact is predicted to be of a highly localised spatial extent, long-term duration, continuous and irreversible (during the lifetime of the project). It is predicted that the impact will affect the fish and shellfish receptors indirectly. Due to the extremely localised spatial extent, the magnitude is therefore, considered to be **negligible**.

### SENSITIVITY OF RECEPTORS

6.12.8 The sensitivities of fish and shellfish receptors to underwater noise are detailed in Table 6.20, Table 6.21 and Table 6.22, and were assessed as having a maximum sensitivity of **high** (for seahorse).

### SIGNIFICANCE OF EFFECT

6.12.9 The impact of operational subsea noise on fish and shellfish receptors within the array areas is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **high**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OFFSHORE EXPORT CABLE CORRIDOR IMPACTS

#### MAGINITUDE OF IMPACTS

6.12.10 Underwater noise during the operational phase within the offshore ECC is predicted to be limited to noise from maintenance vessel traffic servicing the OWF.

6.12.11 Noise levels reported by Malme *et al*. (1989) and Richardson *et al*. (1995) for large surface vessels indicate that physiological damage to fish and shellfish is unlikely, although the levels could be sufficient to cause local disturbance of sensitive marine fauna (e.g., clupeids such as herring, sprat and shad) in the immediate vicinity of the vessel, depending on ambient noise levels.

6.12.12 Considering the underwater noise associated with service vessels, the ambient noise levels within the site would be expected to be lower than those present in the vicinity of nearby shipping lanes.

6.12.13 The impact is predicted to be of a highly localised spatial extent, long-term duration, continuous and irreversible (during the lifetime of the project). It is predicted that the impact will affect the fish and shellfish receptors indirectly. Due to the extremely localised spatial extent, the magnitude is therefore, considered to be **negligible**.

#### SENSITIVITY OF RECEPTORS

6.12.14 The sensitivities of fish and shellfish receptors to underwater noise are detailed in Table 6.20, Table 6.21 and Table 6.22, and were assessed as having a maximum sensitivity of **high** (for seahorse).

#### SIGNIFICANCE OF EFFECT

6.12.15 The impact of operational subsea noise on fish and shellfish receptors within the array areas is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **high**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.16 Impacts may potentially occur within the array area and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

### IMPACT 9: TEMPORARY INCREASE IN SSC AND DEPOSITION ARISING FROM OPERATION AND MAINTENANCE ACTIVITIES

6.12.17 Temporary localised increases in SSC and associated sediment deposition are expected from cable remedial burial and cable repairs within the array areas and offshore ECC. Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes, Volume 6, Part 5, Annex 2.1: Physical Processes Baseline Technical Report and Volume 6, Part 5, Annex 2.2: Physical Processes Model Design and Validation provides a full description of the offshore physical environment assessment, with a summary of the MDSs associated with the impact, as detailed in Table 6.10 of this ES chapter.

## ARRAY AREAS IMPACTS

### MAGNITUDE OF IMPACT

6.12.18 Table 6.10 presents the MDS associated with increases in SSC and deposition from the maintenance and repairs within the array areas.

6.12.19 Cable remedial burial and cable replacement and/ or repairs are both predicted to cause sediment plumes. Plumes are expected to be restricted to within a single tidal excursion from the point of release. Sediment plumes are expected to quickly dissipate after cessation of the activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels. It should be noted that any sediment released from cable protection replenishment will be of a substantially smaller scale than that for cable reburial works as the only sediment released from this activity will be that which arises when the cable protection is placed on the seabed. This is in comparison with sediment released from cable burial works for which it is assumed that the full volume of sediment from the trench is suspended and entrained in the water column.

6.12.20 Each event will be discrete, short term, and of localised extent (within one tidal excursion), and therefore the magnitude of effect is considered to be **negligible**.

### SENSITIVITY OF RECEPTORS

6.12.21 The sensitivities of fish and shellfish receptors to temporary increases in SSC and sediment deposition are detailed in Table 6.27 and were assessed as having a maximum sensitivity of **medium**.

### SIGNIFICANCE OF EFFECT

6.12.22 The impact of increased SSC and sediment deposition of fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OFFSHORE ECC IMPACTS

### MAGNITUDE OF IMPACT

6.12.23 Table 6.10 presents the MDS associated with increases in SSC and deposition from the maintenance and repairs within the offshore ECC.

6.12.24 Cable remedial burial and cable replacement and/ or repairs are both predicted to cause sediment plumes. Plumes are expected to be restricted to within a single tidal excursion from the point of release. Sediment plumes are expected to quickly dissipate after cessation of the activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels. It should be noted that any sediment released from cable protection replenishment within the offshore ECC will be of a substantially smaller scale than that for cable reburial works as the only sediment released from this activity will be that which arises when the cable protection is placed on the seabed. This is in comparison with sediment released from cable burial works for which it is assumed that the full volume of sediment from the trench is suspended and entrained in the water column.

6.12.25 Each event will be discrete, short term, and of localised extent (within one tidal excursion), and therefore the magnitude of effect is considered to be **negligible**.

#### SENSITIVITY OF RECEPTORS

6.12.26 The sensitivities of fish and shellfish receptors to temporary increases in SSC and sediment deposition are detailed in Table 6.27 and were assessed as having a maximum sensitivity of **medium**.

#### SIGNIFICANCE OF EFFECT

6.12.27 The impact of increased SSC and sediment deposition of fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.28 It is considered highly unlikely that major maintenance works will be undertaken simultaneously within the array areas and the offshore ECC, in particular asset reburial or repairs, as these are infrequent occurrences during the lifetime of development.

## IMPACT 10: IMPACTS ON FISHING PRESSURE DUE TO DISPLACEMENT

6.12.29 Changes to fishing pressure may result in reduced fishing pressure within the OL due to the presence of infrastructure, and maintenance activities, and could lead to increased pressure on fish and shellfish within the OL due to displacement of fishing effort into the surrounding area.

### ARRAY AREAS IMPACTS

#### MAGNITUDE OF THE IMPACT

6.12.30 Fishing activity may be reduced within the array areas as a result of the physical presence of the infrastructure, assumed 50 m operating distances around infrastructure and temporary safety zones around infrastructure undergoing major maintenance. Receptors have the potential to be affected by an increase in fishing pressure outside the array areas include those targeted by commercial fisheries occurring within VE (e.g., cockles, whelk, seabass, plaice, thornback ray, red mullet, lobster horse mackerel and sole as key commercial species in the region). It would not be expected that any changes in fishing activities in this area (should these effects occur at all) would lead to changes in populations of these species as any increase would be very localised and any population level effects would be minimised by fisheries management measures (e.g., quotas, days at sea, etc.).

6.12.31 The impact is predicted to be of a local spatial extent (adjacent to the VE array areas), long-term duration, continuous and irreversible (within the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **negligible**.

### SENSITIVITY OF THE RECEPTOR

6.12.32 When regarding the sensitivity of fish and shellfish receptors to the potential increase of fishing pressure outside of the array areas due to displacement, they are considered to be largely insensitive to the impact, with no population level effects anticipated. Fish and shellfish receptors are deemed to be of **low** vulnerability, **high** recoverability and of local to national importance within the VE study area. The sensitivity of these receptors is therefore considered to be **low**.

### SIGNIFICANCE OF THE EFFECT

6.12.33 Potential displacement of fishing activity within the array areas may lead to increases in fishing activity outside of the VE array areas. The extent to which commercial fisheries will be displaced will have a limited effect on fish and shellfish populations in the study area, with fish and shellfish receptors not likely to be sensitive to this change in fishing activity.

6.12.34 Overall, it is predicted that the sensitivity of fish and shellfish receptors to changes in fishing pressure within the array areas is considered to be **low** and the magnitude is deemed to be **negligible**. The effect will therefore be of **negligible** significance, which is not significant in EIA terms.

## OFFSHORE ECC IMPACTS

### Magnitude of the impact

6.12.35 Fishing activity may be reduced within the offshore ECC as a result of the physical presence of the infrastructure, assumed 50 m operating distances around infrastructure and temporary safety zones around infrastructure undergoing major maintenance. Receptors have the potential to be affected by an increase in fishing pressure outside the offshore ECC include those targeted by commercial fisheries occurring within VE (e.g., cockles, whelk, seabass, plaice, thornback ray, red mullet, lobster horse mackerel and sole as key commercial species in the region). It would not be expected that any changes in fishing activities in this area (should these effects occur at all) would lead to changes in populations of these species as any increase would be very localised and any population level effects would be minimised by fisheries management measures (e.g., quotas, days at sea, etc.).

6.12.36 The impact is predicted to be of a local spatial extent (adjacent to the VE offshore ECC), long-term duration, continuous and irreversible (within the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **negligible**.

### SENSITIVITY OF THE RECEPTOR

6.12.37 When regarding the sensitivity of fish and shellfish receptors to the potential increase of fishing pressure outside of the offshore ECC due to displacement, they are considered to be largely insensitive to the impact, with no population level effects anticipated. Fish and shellfish receptors are deemed to be of low vulnerability, high recoverability and of local to national importance within the VE study area. The sensitivity of these receptors is therefore considered to be **low**.

### SIGNIFICANCE OF THE EFFECT

6.12.38 Potential displacement of fishing activity within the array areas may lead to increases in fishing activity outside of the VE array areas. The extent to which commercial fisheries will be displaced will have a limited effect on fish and shellfish populations in the study area, with fish and shellfish receptors not likely to be sensitive to this change in fishing activity.

6.12.39 Overall, it is predicted that the sensitivity of fish and shellfish receptors to changes in fishing pressure within the offshore ECC is considered to be **low** and the magnitude is deemed to be **negligible**. The effect will therefore be of **negligible** significance, which is not significant in EIA terms.

## IMPACT 11: LONG-TERM OR PERMANENT LOSS OF HABITAT DUE TO THE PRESENCE OF WTGS FOUNDATIONS, SCOUR PROTECTION AND CABLE PROTECTION

6.12.40 The presence of infrastructure such as foundations and cable protection at crossings have the potential to impact on fish and shellfish ecology by the removal of essential habitats for survival (e.g., spawning, nursery and feeding habitats).

### ARRAY AREAS IMPACTS

### MAGNITUDE OF IMPACT

6.12.41 Within the array areas the presence of foundations and the associated scour protection, along with the cable protection measures used at inter-array cable crossings and areas where inter-array cable burial is not possible, will lead to a change from a sedimentary habitat to one characterised by hard substrate. This will be a permanent habitat loss (for the design life duration of VE) and a permanent change of habitat.

6.12.42 Table 6.10 identifies the maximum design scenario for foundation, scour and cable protection footprint. The total habitat loss from these components equates to approximately 1.09% of the array areas. The magnitude of the impact that permanent habitat loss/ alteration will have on fish and shellfish ecology receptors is considered to be **low**. While the impact will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected is highly localised and the fish and shellfish species assemblages and habitats are common and widespread throughout the wider region.

## SENSITIVITY OF THE RECEPTORS

6.12.43 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.35 below.

**Table 6.35: Sensitivity of VERs to long-term or permanent habitat loss.**

| VER | Sensitivity Justification |
| --- | --- |
| Demersal spawning VERs (spawning herring and sandeel). | Sandeel are demersal spawners and are reliant upon the presence of suitable substrates for spawning (i.e., sandy sediments). Furthermore, as well as laying demersal eggs, sandeel also have specific habitat requirements throughout their juvenile and adult life history. Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' habitats (as determined by sand content) are located across the array areas. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the array areas as having high confidence that the seabed may be suitable for spawning. However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. Considering the localised nature of the impact, any effects of habitat loss are not likely to have a population level effect on sandeel. Sandeel are consequently deemed to be of **medium** vulnerability to long-term changes in substrate, with limited ability for recovery, and of regional importance within the southern North Sea, and therefore are considered to be of **medium** sensitivity.<br><br>Herring are also demersal spawners, reliant upon the presence of suitable substrates for spawning (i.e., gravelly sediments). The VE southern array area overlaps with an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), and 'Marginal' spawning substrates are located across the array areas (as determined by gravel content (Reach et al., 2013)). A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium confidence that the seabed may be suitable for spawning. However, site specific PSA sampling across the southern array area classifies much of the substrates as 'unsuitable' for spawning. On a broader scale, 'Preferred' spawning substrates, and significantly higher densities of herring |

| VER | Sensitivity Justification |
| --- | --- |
| | larvae (indicative of spawning activity) are located to the south of the array areas, within the Dover Strait, and eastern English Channel. Considering the localised nature of the impact, any effects of habitat loss are not likely to have a population level effect on herring. Herring are deemed to be of **medium** vulnerability to long-term habitat loss, and of regional importance within the southern North Sea, and therefore are considered to be of **medium** sensitivity. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel). | These receptors are pelagic spawners and therefore do not display substrate dependency, and therefore are not considered vulnerable to long-term habitat loss and as such the sensitivity of these species is considered to be **negligible**. |
| VERs of limited mobility (shellfish). | Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be vulnerable to long-term habitat loss during the overwintering period.<br><br>Common cockles They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and are quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007), and therefore are considered potentially sensitive to long-term habitat loss.<br><br>Brown crabs are known to be associated with rocky substrates but also inhabit mixed coarse, sand, and soft sediments (Hall *et al*., 1993). Berried female brown crab bury themselves into soft mud and sand, while brooding eggs in the overwintering period.<br><br>It should be noted however, that common whelk, common cockle and brown crab are substrate dependent rather than being philopatric and can therefore fully utilise adjacent areas which will be unaffected. Therefore, the sensitivity of these receptors is considered to be **low**.<br><br>European lobster are broadly distributed across the southern North Sea and are found across a range of habitats. Lobster are not known to exhibit substrate dependant behaviours and are therefore considered to be of **low** sensitivity to long term or permanent habitat loss.<br><br>All other shellfish VERs are distributed widely throughout the Southern North Sea and are not of high value to fisheries in |

| VER | Sensitivity Justification |
|---|---|
| | the region. As a result of this, all other VERs are considered to be of **low** sensitivity to impacts from long-term habitat loss. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout, smelt and elasmobranchs). | These species do not display substrate dependency, and therefore are not considered vulnerable to long-term habitat loss and as such the sensitivity of these species is considered to be **negligible**. |

### SIGNIFICANCE OF EFFECT

6.12.44 Long-term or permanent habitat loss will represent a long-term and continuous impact throughout the lifetime of the project. However only a relatively small proportion of the fish and shellfish habitats are likely to be affected in the context of wider habitats in the area. Most receptors are predicted to have some tolerance to this impact.

6.12.45 The impact of long-term or permanent habitat loss on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.46 The impact of long-term or permanent habitat loss on spawning Downs herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.47 The impact of long-term or permanent habitat loss on shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.48 The impact of long-term or permanent habitat loss of all other fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## OFFSHORE ECC IMPACTS

### MAGNITUDE OF IMPACT

6.12.49 In the offshore ECC the presence of cable protection will lead to a change from a sedimentary habitat to one characterised by hard substrate. This will be a permanent habitat loss and a permanent change of habitat (for the design life duration of VE). It is assessed here as permanent habitat loss and a potential negative effect (due to the potential shift in the baseline condition), although it is noted that this also has the potential to comprise beneficial effects, providing new habitats for different faunal assemblages to colonise, resulting in a likely increase in biodiversity and biomass.

6.12.50 Table 6.10 identifies the maximum design scenario for cable protection footprint which equates to approximately 0.25% of the ECC corridor

6.12.51 The magnitude of the impact that permanent habitat loss/ alteration will have on fish and shellfish ecology receptors is considered to be **low**. While the impact will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected is highly localised and the fish and shellfish species assemblages and habitats are common and widespread throughout the wider region.

## SENSITIVITY OF THE RECEPTORS

**Table 6.36: Sensitivity of VERs to long-term or permanent habitat loss.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | Sandeel are demersal spawners and are reliant upon the presence of suitable substrates for spawning (i.e., sandy sediments). Furthermore, as well as laying demersal eggs, sandeel also have specific habitat requirements throughout their juvenile and adult life history.<br><br>Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' and 'Marginal' habitats (on account of sand content) are located across the offshore ECC. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the nearshore portion of the ECC as having low confidence that the seabed may be suitable for spawning, due to the presence of 'Preferred' sandeel habitat, but the absence of a defined historic spawning ground. The offshore portion of the ECC was classified as having medium confidence that the seabed may be suitable for spawning, due to the presence of 'Marginal' habitat, and the overlap with a defined spawning ground (Coull et al., 1998). However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel.<br><br>Sandeel are consequently deemed to be of **medium** vulnerability to long-term or permanent changes in substrate, with limited ability for recovery, and of regional importance within the southern North Sea, and therefore are considered to be of **medium** sensitivity.<br><br>Herring are also demersal spawners, reliant upon the presence of suitable substrates for spawning (i.e., gravelly |

| VER | Sensitivity Justification |
|---|---|
| | sediments). There is no direct overlap of the offshore ECC with the Blackwater herring stock spawning ground, and therefore there will be no impact from long term or permanent habitat loss on spawning Blackwater herring stock. Spawning herring from the Blackwater spawning stock are therefore considered to be of **negligible** sensitivity to long-term or permanent habitat loss. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat). | These receptors are pelagic spawners and therefore do not display substrate dependency, and therefore are not considered vulnerable to long-term or permanent habitat loss and as such the sensitivity of these species is considered to be **negligible**. |
| VERs of limited mobility (shellfish). | Common whelk are broadly distributed across the southern North Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be vulnerable to long-term habitat loss during the overwintering period.<br><br>Common cockles They are of commercial value to fisheries within the region. Common cockle are adapted to life in a sedimentary environment and are quite capable of burrowing into fine and coarse sediments (Tyler-Walters, 2007), and therefore are considered potentially sensitive to long-term or permanent habitat loss.<br><br>European lobster are broadly distributed across the southern North Sea and are found across a range of habitats. Lobster are not known to exhibit substrate dependant behaviours, and are therefore not considered particularly sensitive to long term or permanent habitat loss.<br><br>Brown crabs are known to be associated with rocky substrates but also inhabit mixed coarse, sand, and soft sediments (Hall *et al*., 1993). Berried female brown crab bury themselves into soft mud and sand, while brooding eggs in the overwintering period.<br><br>Native oyster and native oyster beds are a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ. As stated above, there is no direct overlap of the offshore ECC with the Blackwater, Crouch, Roach and Colne Estuaries MCZ, and therefore no impacts on native oyster as a feature of the MCZ are anticipated. Native oyster as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ are therefore considered to be of **negligible** sensitivity to long-term habitat loss. |

| VER | Sensitivity Justification |
|---|---|
| | Native oyster are broadly distributed across the southern North Sea and are of commercial value to fisheries within the region. Native oysters are permanently fixed to the substratum and therefore would not be able to flee from disturbance.<br>It should be noted however, that common whelk, common cockle, brown crab and native oyster are substrate dependent rather than being philopatric and can therefore fully utilise adjacent areas which will be unaffected. Therefore, the sensitivity of these receptors is considered to be **low**.<br>All other shellfish VERs are distributed widely throughout the Southern North Sea and are not of high value to fisheries in the region. As a result of this, all other VERs are considered to be of **low** sensitivity to impacts from long-term or permanent habitat loss. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout, smelt and elasmobranchs). | These species do not display substrate dependency, and therefore are not considered vulnerable to long-term or permanent habitat loss and as such the sensitivity of these species is considered to be **negligible**. |

### SIGNIFICANCE OF EFFECT

6.12.52 Long-term or permanent habitat loss will represent a long-term and continuous impact throughout the lifetime of the project. However only a relatively small proportion of the fish and shellfish habitats are likely to be affected in the context of wider habitats in the area. Most receptors are predicted to have some tolerance to this impact.

6.12.53 The impact of long-term or permanent habitat loss on sandeel is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.54 The impact of long-term or permanent habitat loss on spawning Blackwater herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.12.55 The impact of long-term or permanent habitat loss on native oyster as designated as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.12.56 The impact of long-term or permanent habitat loss on shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.57 The impact of long-term or permanent habitat loss of all other fish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.58 Direct impacts from permanent habitat loss and alteration will occur within the array area and offshore ECC and may bridge between the two areas. The impacts will be within the direct footprint of the infrastructure with no additive spatial overlap.

### IMPACT 12: INCREASED HARD SUBSTRATE AND STRUCTURAL COMPLEXITY AS A RESULT OF THE INTRODUCTION OF WTGS FOUNDATIONS, SCOUR PROTECTION AND CABLE PROTECTION

6.12.59 Any introduction of infrastructure such as foundations and scour protection would result in the introduction of hard substrate to the currently predominantly soft seabed habitat of the OL. This would result in an increase in the heterogeneity of the seabed habitat and a change of the composition of the benthic community. As a result, an increase in the biodiversity of the benthic community in the vicinity of the area where hard substrate is introduced is expected to occur (Wilhelmsson and Malm, 2008). This increase in diversity and productivity of the seabed communities expected may have an impact on fish and shellfish receptors, resulting in either attraction or increased productivity.

6.12.60 Furthermore, there is a risk that the introduction of hard substrate into a sedimentary habitat will enable the colonisation of the introduced substrate by invasive/ non-indigenous species that might otherwise not have had a suitable habitat for colonisation, thereby enabling their spread. Mitigation measures, including a PEMP with a marine biosecurity plan (Table 6.11) will, however, ensure that the risk of potential introduction and spread of INNS will be minimised as low as practicable.

#### ARRAY AREAS IMPACTS

#### MAGNITUDE OF IMPACT

6.12.61 The maximum area of new hard substrate that is likely to be created in VE as a result of foundation installation, scour protection and cable protection, is presented in Table 6.10, and equates to approximately 1.1 % of the array areas. The potential impact is predicted to be of local spatial extent (within the OL), and of long-term duration, continuous and irreversible (during the lifetime of the project), and therefore the magnitude of effect is therefore considered to be **low**.

#### SENSITIVITY OF THE RECEPTOR

6.12.62 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.37 below.

**Table 6.37: Sensitivity of VERs to increased hard substrate and structural complexity.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | Due to the demersal nature of sandeel and herring spawning, and their specific habitat requirements, they are considered to be vulnerable to the impact, of high vulnerability to permanent changes in the substrate, with no ability for recovery, and of regional importance.<br><br>Sandeel preferred habitats and spawning areas are typically dominated by coarse sediments and sandy habitats. Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' habitats (as determined by sand content) are located across the array areas. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the array areas as having high confidence that the seabed may be suitable for spawning. However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. Sandeel are high vulnerability to direct damage and disturbance, with medium recoverability (due to the temporary nature of the impact) and are considered to be of regional importance. Considering the localised nature of the impact, any effects of from the introduction of hard substrates into the array areas are not likely to have a population level effect on sandeel. Sandeel are consequently deemed to be of medium vulnerability to increased hard substrate and structural complexity, with limited ability for recovery, and of regional importance within the southern North Sea, and therefore are considered to be of **medium** sensitivity.<br><br>Herring are also demersal spawners, reliant upon the presence of suitable substrates for spawning (i.e., gravelly sediments). The VE southern array area overlaps an area identified as part of the wider Downs herring spawning grounds (as defined by Coull et al., 1998), and 'Marginal' spawning substrates are located across the array areas (as determined by gravel content (Reach et al., 2013)). A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the southern array area as having medium confidence that the seabed may be suitable for spawning. However, site specific PSA sampling across the southern |

| VER | Sensitivity Justification |
| --- | --- |
| | array area classifies much of the substrates as 'unsuitable' for spawning. On a broader scale, 'Preferred' spawning substrates, and significantly higher densities of herring larvae (indicative of spawning activity) are located to the south of the array areas, within the Dover Strait, and eastern English Channel. Considering the localised nature of the impact, any effects of increased hard substrate in the array areas are not likely to have a population level effect on herring. Herring are deemed to be of medium vulnerability to increased hard substrate and structural complexity, with limited ability for recovery, and of regional importance within the southern North Sea, and therefore are considered to be of **medium** sensitivity. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel). | Being pelagic spawners and having widespread distributions, these VERs are considered to be of low vulnerability and medium recoverability and so are assessed as being of **negligible** sensitivity. |
| VERs of limited mobility (shellfish). | There is the potential for positive effects on crustacean species, such as brown crab and lobster, due to expansion of their natural habitats (Linley *et al*., 2007) and the creation of additional refuge areas. Novel habitats and new potential food sources may be created from foundations and scour protection installed in areas of sandy and coarse sediments, which could extend the habitat ranges of some shellfish species. However, the colonisation of new habitats by shellfish receptors could lead to the introduction of non-indigenous and invasive species, this may have indirect adverse effects on shellfish populations as a result of competition. However, the implementation of a PEMP, which will include a biosecurity plan, will ensure that the risk of potential introduction and spread of Invasive Non-Native Species (INNS) will be minimised. Taking the above into consideration, shellfish receptors are deemed to not be vulnerable to increased hard substrate and structural complexity and are considered to be of local to regional importance to the area. Shellfish are therefore considered to be of **low** sensitivity to this impact. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs). | These species do not display substrate dependency, and therefore are not considered vulnerable to increased hard substrate and as such the sensitivity of these species is considered to be **negligible**. |

## SIGNIFICANCE OF EFFECT

6.12.64 There is some uncertainty associated with the likely effects of introduction of hard substrates into the marine environment on fish and shellfish receptors. Fish populations are unlikely to show noticeable benefits as a result of this impact, though there is evidence that shellfish populations (particularly brown crab and lobster) would benefit from the introduction of hard substrates (Roach and Cohen, 2015; Hooper and Austen, 2014; Krone *et al*., 2013). Demersal spawners, herring and sandeel, are considered to have increased sensitivity to the introduction of hard substrate, due to their specific habitat requirements.

6.12.65 The impact of increased hard substrate and structural complexity on sandeel is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.66 The impact increased hard substrate and structural complexity on spawning Downs stock herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.67 The impact increased hard substrate and structural complexity on shellfish is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.68 The impact increased hard substrate and structural complexity on all other fish receptors is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

## OFFSHORE ECC IMPACTS

## MAGNITUDE OF IMPACT

6.12.69 The introduction of hard substrate in the form of cable protection will change the type of available habitats within the array areas and offshore ECC. However, the amount of introduced substrate is relatively small (Table 6.10) amounting to approximately 0.25% of the total offshore ECC.

6.12.70 The impact is therefore predicted to be of local spatial extent, long-term duration but reversable once the infrastructure is removed, although it is likely that cable protection will remain in situ. Despite this the magnitude of the impact is deemed to be **negligible**, as the habitats are not geographically restricted and are typically common and widespread throughout the wider region.

## SENSITIVITY OF RECEPTORS

6.12.71 The sensitivity rating assigned to each VER, and associated justification is provided in

6.12.72 Table 6.37 below.

**Table 6.38: Sensitivity of VERs to increased hard substrate and structural complexity within the offshore ECC.**

| VER | Sensitivity Justification |
|---|---|
| Demersal spawning VERs (spawning herring and sandeel). | Due to the demersal nature of sandeel and herring spawning, and their specific habitat requirements, they are considered to be vulnerable to the impact, of **high** vulnerability to permanent changes in the substrate, with no ability for recovery, and of regional importance.<br><br>Sandeel preferred habitats and spawning areas are typically dominated by coarse sediments and sandy habitats. Parts of the offshore ECC are located in preferred sandeel habitats and spawning grounds. Potential sandeel spawning grounds (as defined by Coull et al., 1998), and 'Preferred' and 'Marginal' habitats (on account of sand content) are located across the offshore ECC. A heatmapping exercise (as detailed in Volume 6, Part 5, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report) identified the nearshore portion of the ECC as having low confidence that the seabed may be suitable for spawning, due to the presence of 'Preferred' sandeel habitat, but the absence of a defined historic spawning ground. The offshore portion of the ECC was classified as having medium confidence that the seabed may be suitable for spawning, due to the presence of 'Marginal' habitat, and the overlap with a defined spawning ground (Coull et al., 1998). However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea. Potential sandeel habitats and spawning grounds are located across the southern North Sea, and eastern English Channel. Sandeel are consequently deemed to be of **medium** vulnerability to increased hard substrate and structural complexity, with limited ability for recovery, and of regional importance within the southern North Sea, and therefore are considered to be of **medium** sensitivity.<br><br>Herring spawning habitats are widely distributed across the southern North Sea and English Channel, and any impacts on this species will be relatively small in the context of the spawning habitat available. There is no direct overlap of the offshore ECC with the Blackwater herring stock spawning ground (the nearest spawning ground to the offshore ECC), and therefore there will be no impact from the introduction of hard substrates into the offshore ECC on spawning Blackwater herring stock. Spawning herring from the Blackwater spawning stock are therefore considered to be of |

| VER | Sensitivity Justification |
|---|---|
| | **negligible** sensitivity to increased hard substrate and structural complexity. |
| Pelagic spawning VERs with spawning grounds overlapping VE (cod, common sole, lemon sole, plaice, whiting, sprat). | Being pelagic spawners and having widespread distributions, these VERs are considered to be of **low** vulnerability and **medium** recoverability and so are assessed as being of **negligible** sensitivity. |
| VERs of limited mobility (shellfish). | There is the potential for positive effects on crustacean species, such as brown crab and lobster, due to expansion of their natural habitats (Linley *et al*., 2007) and the creation of additional refuge areas. Novel habitats and new potential food sources may be created from foundations and scour protection installed in areas of sandy and coarse sediments, which could extend the habitat ranges of some shellfish species. However, the colonisation of new habitats by shellfish receptors could lead to the introduction of non-indigenous and invasive species, this may have indirect adverse effects on shellfish populations as a result of competition. However, the implementation of a PEMP, which will include a biosecurity plan, will ensure that the risk of potential introduction and spread of Invasive Non-Native Species (INNS) will be minimised. Taking the above into consideration, shellfish receptors are deemed to not be vulnerable to increased hard substrate and structural complexity and are considered to be of local to regional importance to the area. Shellfish are therefore considered to be of **low** sensitivity to this impact.<br><br>Native oyster and native oyster beds are a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ. There is no direct overlap of the offshore ECC with the Blackwater, Crouch, Roach and Colne Estuaries MCZ, and therefore no impacts on native oyster as a feature of the MCZ are anticipated. Native oyster as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ are therefore considered to be of **negligible** sensitivity to increased hard substrate and structural complexity. |
| Mobile VERs (dab, tub gurnard, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout, smelt and elasmobranchs). | These species do not display substrate dependency, and therefore are not considered vulnerable to increased hard substrate and as such the sensitivity of these species is considered to be **negligible**. |

SIGNIFICANCE OF EFFECT

6.12.73 The impact of increased hard substrate and structural complexity on sandeel is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.12.74 The impact increased hard substrate and structural complexity on spawning Blackwater herring is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.12.75 The impact of increased hard substrate and structural complexity on native oyster as designated as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

6.12.76 The impact increased hard substrate and structural complexity on shellfish is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to **be minor adverse**, which is not significant in EIA terms.

6.12.77 The impact increased hard substrate and structural complexity on all other fish receptors is considered to be of **low** magnitude, and the sensitivity of the receptor is considered to be **negligible**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.78 Direct impacts from increased hard substrate and structural complexity will occur within the array area and offshore ECC and may bridge between the two areas. The impacts will be within the direct footprint of the infrastructure with no additive spatial overlap.

### IMPACT 13: EMF EFFECTS ARISING FROM CABLES DURING OPERATIONAL PHASE

6.12.79 Electromagnetic fields (EMF) are produced as a result of the electricity passing through the cables (inter-array and export cables). EMFs will result from operation of up to 250 km of inter-array cable and 370 km of export cable. Three different EMF types can be generated by offshore wind cables: electric fields (E fields); magnetic fields (B fields); and induced electric fields (iE fields). Industry standard offshore wind cables all contain shielding which prevents E fields from passing into the marine environment and as such, these are not considered any further.

6.12.80 Cable shielding does not however significantly alter or prevent the emission of B fields. It is the movement of the B fields within a medium (i.e., seawater) which then causes the iE fields. These iE fields can either be produced by the movement of the alternating B field (in the case of alternating current (AC) transmission) through the seawater or by the movement of seawater and/or an organism through a static B field (in the case of direct current (DC) transmission).

## ARRAY AREAS IMPACTS

### MAGNITUDE OF IMPACT

6.12.81 Many fish and shellfish species are thought to be able to sense electric and magnetic fields, with some species having developed specialised organs to facilitate this. The most well-known example of these are the Ampullae of Lorenzini in elasmobranchs, with this group of animals using electroreceptors to find prey. iE fields may cause either attraction or repulsion, with varying strength fields having been demonstrated to cause both reactions (Gill and Taylor 2001; Yano *et al.,* 2000; Kalmijn, 1982; Kimber *et al.,* 2011). The threshold for the change between attraction and avoidance of E fields in elasmobranchs is considered to be between 400 - 1,000µV/m (reviewed in CMACS, 2012) and these levels would only likely be found at or within 1 - 2 metres of the seabed for a cable buried at 1m. For deeper burial, the iE field at the seabed would be correspondingly lower.

6.12.82 In a review by Tricas and Gill (2011), it was noted that the sensitivity of elasmobranchs to E fields was highest at frequencies of 1 - 10 Hz, with a broader response frequency range of 0.01 - 25 Hz where fields intensities of 10x or greater were required to elicit a reaction. This suggests that weak fields such as those generated by offshore wind AC cables are likely to be mostly undetectable.

6.12.83 Some fish species are known to have magneto-receptors, with this thought to primarily be for the purposes of navigation (Walker *et al*., 1997). However, most of the research to date on magneto-reception in fish has been undertaken in migratory species such as Salmonidae, Anguillidae and Scombridae, with information on other species being limited (reviewed in Tricas and Gill, 2011). There have been suggestions (Gill and Kimber, 2005) that the presence of magnetic fields generated by cables may interrupt navigation and consequently migration.

6.12.84 EMFs monitored around subsea electricity cables have been shown to attenuate exponentially vertically and horizontally away from the cables, with the magnetic field generated by the cables typically having reached zero within 10 m of the cable (reviewed by Tricas and Gill, 2011). Burial of the cables and protection with cable protection where shallow buried or surface laid will not reduce the strength of the fields, however, it moves the cables further from the receptors, and as such the receptors will be subject to reduced field strengths.

6.12.85 The impact is predicted to be highly localised, long-term duration, continuous and irreversible (within the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **low**.

### SENSITIVITY OF THE RECEPTOR

6.12.86 The evidence on behavioural reactions of elasmobranchs due to iE fields from offshore wind cables is limited, with some studies showing small changes in behaviour when near to the cable compared to when not (Gill *et al*., 2009), however the behavioural changes appeared to be dependent on the individual rather than consistent and as such the population consequences are uncertain.

6.12.87 Studies on European eel have shown some deviation from migratory routes in response to low (5μT) DC B fields, however, the effects were short-term and short scale and not thought to impact on overall migration (Westerberg, 2000; Ohman *et al*., 2007). Interestingly, no effects were seen in European eel from AC fields of 9.6μT (Orpwood *et al*., 2015), suggesting that there may be differences in effects between DC and AC cabling. A review of potential effects of EMF on migratory fish for Scottish Natural Heritage (Gill and Bartlett, 2010) identified that there was insufficient evidence to be able to confirm whether any impacts would arise from the field strengths generated by OWF cabling.

6.12.88 A broad scale study of fish aggregations and directional movement around cables at Nysted OWF in Denmark, showed no evidence of any change in directionality or distribution of species as a result of the cable installation (Hvidt *et al*., 2004).

6.12.89 Many marine invertebrates are thought to be magneto-sensitive, with this often being used for navigational purposes (migration etc.). However, evidence for potential impacts from anthropogenic B fields is limited and can be contradictory even within the same species. Studies on the green shore crab (*Carcinus maenas*) have been directly contradictory, with one study demonstrating reduced aggression in response to AC B fields matching those from an OWF (Everitt, 2008), however, another study showed no effects from static B fields (Bochert and Zettler, 2004). Brown shrimp (*Crangon crangon*) were recorded as being attracted to B fields of the magnitude expected from offshore wind cabling (ICES, 2003). One recent study (Hutchison *et al*., 2020) has suggested potential changes to exploratory behaviour in American lobster (*Homarus americanus*) in response to DC B fields when in tanks placed near a subsea cable.

6.12.90 Based on the above information, whilst it is possible that some fish and shellfish species present within the area around VE may be able to detect the iE or B fields generated by the cables, it is unlikely that the field strengths will disrupt feeding, spawning or migratory behaviours. As such, the sensitivity of all species is assessed as **low**.

### SIGNIFICANCE OF EFFECT

6.12.91 The impact from EMF effects generated by inter-array cables during operational phase is considered to be of **low** magnitude, and the **low** maximum sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OFFSHORE ECC IMPACTS

### MAGNITUDE OF IMPACT

6.12.92 The magnitude of impact is the same as described for the array areas in paragraph 6.12.85 *et seq*. The magnitude of impact is assessed as **low**.

### SENSITVITY OF THE RECEPTOR

6.12.93 The overview of sensitivity is the same as described for the array areas in paragraph 6.12.90 *et seq*. The sensitivity of the receptors is assessed as **low**.

### SIGNIFICANCE OF THE EFFECT

6.12.94 The impact from emf effects generated by export cables during operational phase is considered to be of **low** magnitude, and the **low** maximum sensitivity of the receptors is considered to be low. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.95 Impacts may potentially occur within the array area and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no significant additive spatial overlap.

## IMPACT 14: DIRECT DAMAGE (E.G. CRUSHING) AND DISTURBANCE TO MOBILE DEMERSAL AND PELAGIC FISH AND SHELLFISH SPECIES ARISING FROM OPERATION AND MAINTENANCE ACTIVITIES

6.12.96 Direct disturbance is likely to occur during the operational phase of VE as a result of major repairs within the array (including jack-up operations, cable repairs/ replacements, and repairs to OSSs and accommodation platforms), along the cable corridor (cable reburial, protection replacement and cable repairs/replacements).

### ARRAY AREAS IMPACTS

### MAGNITUDE OF IMPACT

6.12.97 The maximum area of disturbance to subtidal habitat will arise from cable repair and/ or replacement during the operation and maintenance phase of the development (including de-burial and reburial of inter array cables within the array areas). The maximum area of direct damage is presented in Table 6.10, and equates to approximately 1.1% of the array areas over the operational lifetime of VE. Given that the habitats are common and widespread throughout the region impacts from the individual O&M activities will represent a very small footprint compared to their overall extent.

6.12.98 Due to the predicted local spatial extent, short-term duration and intermittent and reversible nature of the impact, the magnitude of the will be **low.**

### SENSITIVITY OF THE RECEPTOR

6.12.99 The sensitivities of fish and shellfish receptors to direct damage and disturbance are detailed in Table 6.31 and were assessed as having a maximum sensitivity of **medium**.

### SIGNIFICANCE OF THE EFFECT

6.12.100 The impact of direct damage and disturbance of fish and shellfish receptors is considered to be a maximum of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OFFSHORE ECC IMPACTS

### MAGNITUDE OF IMPACT

6.12.101 The maximum area of disturbance to subtidal habitat will arise from cable repair and/ or replacement during the operation and maintenance phase of the development (including de-burial and reburial of export cables). The maximum area of direct damage is presented in Table 6.10 and equates to approximately 0.3% of the offshore ECC over the operational lifetime of VE. Given that the habitats are common and widespread throughout the region impacts from the individual O&M activities will represent a very small footprint compared to their overall extent.

6.12.102 Due to the predicted local spatial extent, short-term duration and intermittent and reversible nature of the impact, the magnitude of the impact will be **low**.

### SENSITIVITY OF THE RECEPTOR

6.12.103 The sensitivities of fish and shellfish receptors to direct damage and disturbance are detailed in Table 6.31 and were assessed as having a maximum sensitivity of **medium**.

### SIGNIFICANCE OF THE EFFECT

6.12.104 The impact of direct damage and disturbance of fish and shellfish receptors is considered to be a maximum of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## IMPACT 15: ACCIDENTAL POLLUTION EVENTS DURING THE OPERATION AND MAINTENANCE PHASE RESULTING IN POTENTIAL EFFECTS ON FISH AND SHELLFISH RECEPTORS

6.12.105 Accidental spillage of chemicals and substances from vessels used in maintenance activities, from offshore fuel storage tanks and from the WTGs and OSPs themselves may impact on fish and shellfish, resulting in behavioural effects such as moving away from affected areas and prevention of spawning. Chemical spills may also have sub-lethal to lethal effects dependent on the life stage of the organism, exposure level and the level of toxicity.

## ARRAY AREAS IMPACTS

### MAGNITUDE OF IMPACT

6.12.106 The magnitude of the impact is entirely dependent on the nature of the pollution incident but it is recognised that the potential for accidental loss is generally limited due to the small inventories contained on the installations (DECC, 2011). Any spill or leak within the array areas would be subject to immediate dilution and rapid dispersal.

6.12.107 Given the mitigation (Table 6.11) which is proposed for the operation and maintenance phase (i.e., a Project Environmental Management Plan), it is considered that the likelihood of accidental release is extremely low.

6.12.108 The impact is predicted to be of local to regional spatial extent, short term duration, intermittent and reversible. It is predicted that the impact will affect the receptor directly and indirectly, though the risk of a spill occurring is small. The magnitude is therefore, considered to be **low**.

### SENSITIVITY OF RECEPTOR

6.12.109 The sensitivity of the receptors will vary depending on a range of factors including species and life stage with adult fish less likely to be affected by marine pollution, due to their increased mobility, compared to fish eggs, larvae, juveniles and shellfish species. Any such pollution events will therefore have varying levels of effect dependent on the species present, and pollutants involved. However, as fuel and oil spills are likely to be dispersed on the surface, effects on fish and shellfish receptors are likely to be limited. The sensitivities of fish and shellfish receptors to marine pollution are detailed in Table 6.29, and were assessed as having a maximum sensitivity of **medium**.

### SIGNIFICANCE OF EFFECT

6.12.110 The impact of accidental pollution on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## OFFSHORE ECC IMPACTS

### MAGNITUDE OF IMPACT

6.12.111 The magnitude of the impact is entirely dependent on the nature of the pollution incident but it is recognised that the potential for accidental loss is generally limited due to the small inventories contained on the installations (DECC, 2011). Any spill or leak within the offshore ECC would be subject to immediate dilution and rapid dispersal.

6.12.112 Given the mitigation (Table 6.11) which is proposed for the operation and maintenance phase (i.e., a Project Environmental Management Plan), it is considered that the likelihood of accidental release is extremely low.

6.12.113 The impact is predicted to be of local to regional spatial extent, short term duration, intermittent and reversible. It is predicted that the impact will affect the receptor directly and indirectly, though the risk of a spill occurring is small. The magnitude is therefore, considered to be **low**.

### SENSITIVITY OF RECEPTOR

6.12.114 The sensitivity of the receptors will vary depending on a range of factors including species and life stage with adult fish less likely to be affected by marine pollution, due to their increased mobility, compared to fish eggs, larvae, juveniles and shellfish species. Any such pollution events will therefore have varying levels of effect dependent on the species present, and pollutants involved. However, as fuel and oil spills are likely to be dispersed on the surface, effects on fish and shellfish receptors are likely to be limited. The sensitivities of fish and shellfish receptors to marine pollution are detailed in Table 6.29, and were assessed as having a maximum sensitivity of **medium**.

#### SIGNIFICANCE OF EFFECT

6.12.115 The impact of accidental pollution on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.116 Impacts may potentially occur within the array area and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

## IMPACT 16: TEMPORARY HABITAT LOSS/DISTURBANCE

6.12.117 Temporary habitat loss/ is likely to occur during the operational phase of VE as a result of impacts from maintenance operations including jack-up operations and export cable and inter array cable reburial/ replacement works (where necessary). The impacts associated with these operations are likely to be similar in nature to those associated with the construction phase.

### ARRAY AREAS IMPACTS

#### MAGNITUDE OF IMPACT

6.12.118 Ongoing operations and maintenance are assumed to involve up to five jack-up barge operations per WTGs/offshore structure over the operational lifetime. Impacts will be limited to the area around the WTGs foundations. The spatial extent of this impact is very localised, equating approximately 1.1% of the array areas. Similarly, subtidal cable reburial works (if/when necessary) will affect habitats in the immediate vicinity of cable reburial operations should these be required over the lifetime of the project.

6.12.119 The impact is predicted to be of a highly localised spatial extent, short term duration, intermittent and reversible. It is predicted that the impact will affect the fish and shellfish receptors directly. The magnitude is therefore considered to be **low**.

#### SENSITIVITY OF RECEPTORS

6.12.120 The sensitivities of fish and shellfish receptors to temporary habitat loss are detailed in Table 6.33 and were assessed as having a maximum sensitivity of **medium**.

#### SIGNIFICANCE OF EFFECT

6.12.121 The impact of temporary habitat loss on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OFFSHORE ECC IMPACTS

#### MAGNITIDE OF IMPACT

6.12.122 Temporary subtidal habitat loss will arise from the use of jack-up vessels for operational and maintenance activities as well as from export cable maintenance and replacement. The total MDS is presented in Table 5.12, which is predicted to arise over the design life of VE equating to approximately 0.3% of the offshore ECC.

6.12.123 Cable replacement works will require de-burial and re-burial of a cable or cable sections and along with cable preventative maintenance, including re-burial, will consequently result in temporary habitat loss/disturbance. However, the impacts from these works will be spread over the life span of operation and maintenance activities with only a limited number of activities occurring within any one year.

6.12.124 The magnitude of temporary habitat disturbance from cable maintenance activities is considered to be **low**.

#### SENSITIVITY OF RECEPTORS

6.12.125 The sensitivities of fish and shellfish receptors to temporary habitat loss are detailed in Table 6.33 and were assessed as having a maximum sensitivity of **medium**.

#### SIGNIFICANCE OF EFFECT

6.12.126 The impact of temporary habitat loss on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### OVERLAP BETWEEN ARRAY AREAS IMPACTS AND OFFSHORE ECC IMPACTS

6.12.127 Impacts will occur within the array area and offshore ECC and may bridge between the two areas. The impacts will be localized with no additive spatial overlap.

## 6.13 ENVIRONMENTAL ASSESSMENT: DECOMMISSIONING PHASE

### IMPACT 17: MORTALITY, INJURY, BEHAVIOURAL IMPACTS AND AUDITORY MASKING ARISING FROM NOISE AND VIBRATION

### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.1 Decommissioning of offshore infrastructure within the array areas may result in temporarily elevated underwater noise levels which may have effects on fish and shellfish species, with subsequent effects on spawning and nursery habitats. These elevated noise levels may be due to increased vessel movements and removal of the foundations with the resulting noise levels dependant on the method used for removal of the foundation. The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. The maximum levels of underwater noise during decommissioning would be from underwater cutting required to remove structures, with piled foundations cut approximately 1 m below the seabed. The noise levels from this process are expected to be much less than pile driving and therefore impacts would be less than as assessed during the construction phase.

6.13.2 Studies of underwater noise (decommissioning techniques) reported source levels which are similar to those reported for medium sized surface vessels and ferries (Malme *et al*. 1989; Richardson *et al*., 1995). The noise resulting from wind turbine decommissioning employing abrasive cutting is unlikely to result in any injury, avoidance or significant disturbance of fish and shellfish receptors. Some temporary minor disturbance might be experienced in the immediate vicinity of the decommissioning activity, for example, from dynamically positioned (DP) vessels. The impact is predicted to be of highly local spatial extent, short-term duration intermittent and reversible.

6.13.3 The impact of underwater noise on fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptors is considered to be **high**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 18: TEMPORARY INCREASE IN SSC AND SEDIMENT DEPOSITION

#### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.4 Temporary increases in SSC and sediment deposition from the decommissioning works will be similar (or less) to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed Section 6.11, Impact 2.

6.13.5 To summarise, increases in SSC and sediment deposition will represent a temporary and short-term intermitted impact, with a highly localised impact, affecting a small proportion of the fish and shellfish habitats within the study area.

6.13.6 The impact of increased SSC and sediment deposition on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 19: DIRECT AND INDIRECT SEABED DISTURBANCE LEADING TO THE RELEASE OF SEDIMENT CONTAMINANTS

#### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.7 Direct and indirect seabed disturbances leading to release of sediment contaminants from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.11, Impact 3.

6.13.8 To summarise, the resuspension of contaminants as a result of sediment disturbance is predicted to occur on a small scale, with contaminants predicted to be rapidly dispersed by the tide.

6.13.9 The impact of disturbance leading to the release of sediment contaminants on fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 20: IMPACTS ON FISHING PRESSURE DUE TO DISPLACEMENT

#### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.10 Impacts to fishing pressure due to displacement from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.11, Impact 4.

6.13.11 To summarise, limited displacement of fishing activity within the VE array areas may lead to increases in fishing activity outside the array area. The extent to which commercial fisheries will be displaced will have a limited effect on fish and shellfish populations in the study area, with fish and shellfish receptors not likely to be sensitive to this change in fishing activity.

6.13.12 The impact of changes to fishing pressure on fish and shellfish receptors is considered to be of **negligible** magnitude, and the maximum sensitivity of the receptor is considered to be **low**. The significance of the residual effect is therefore concluded to be **negligible**, which is not significant in EIA terms.

### IMPACT 21: DIRECT DAMAGE (E.G. CRUSHING) AND DISTURBANCE TO MOBILE AND DEMERSAL FISH AND SHELLFISH SPECIES ARISING FROM DECOMMISSIONING ACTIVITIES

#### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.13 Direct damage and disturbance from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.11, Impact 5.

6.13.14 To summarise, the direct damage and disturbance of fish and shellfish receptors will represent a spatially discrete impact, of short term and intermittent nature, affecting a small proportion of the fish and shellfish populations within the study area.

6.13.15 The impact of direct damage and disturbance of fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 22: ACCIDENTAL POLLUTION EVENTS DURING THE DECOMMISSIOING PHASE RESULTING IN POTENTIAL EFFECTS ON FISH AND SHELLFISH RECEPTORS

#### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.16 Accidental pollution events during the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.11, Impact 6.

6.13.17 To summarise, accidental pollution events are predicted to occur on a small scale, with pollutants predicted to be rapidly dispersed by the tide.

6.13.18 The impact of accidental pollution on fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptors is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 23: TEMPORARY HABITAT LOSS/DISTURBANCE

#### ARRAY AREAS AND OFFSHORE ECC IMPACTS

6.13.19 Temporary habitat loss/disturbance from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.11, Impact 7.

6.13.20 To summarise, temporary habitat loss or disturbance from decommissioning works will represent a spatially discrete impact, of short term and intermittent nature, affecting a small proportion of the fish and shellfish habitats within the study area.

6.13.21 The impact of temporary habitat loss/disturbance of fish and shellfish receptors is considered to be of **low** magnitude, and the maximum sensitivity of the receptor is considered to be **medium**. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## 6.14 ENVIRONMENTAL ASSESSMENT: CUMULATIVE EFFECTS

6.14.1 This cumulative impact assessment for fish and shellfish ecology has been undertaken in accordance with the methodology provided in Volume 6, Part 1, Annex 3.1: Cumulative Effects Assessment Methodology.

6.14.2 The projects and plans selected as relevant to the assessment of impacts to fish and shellfish ecology are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and scoped in or out, on the basis of effect–receptor pathway, data confidence and the temporal and spatial scales involved. For the purposes of assessing the impact of the VE on fish and shellfish in the region, the cumulative effect assessment technical note submitted through the EIA Evidence Plan and forming Volume 6, Part 1, Annex 3.1:

Cumulative Effects Assessment Methodology of this ES screened in a number of projects and plans as presented in Table 6.40 and are illustrated in Figure 6.18.

6.14.3 For potential effects on fish and shellfish, planned projects were screened into the assessment based on a screening range that encapsulates the VE fish and shellfish study area as defined by the secondary ZoI, which has been defined based on the expected maximum distance that water from within the OL might be transported on a single mean spring tide, in the flood and/or ebb direction. An additional screening range of 100 km has also been applied around the array areas to encapsulate potential cumulative impacts from underwater noise. This screening area therefore encompasses the extent of impacts from fish and shellfish ecology associated with VE.

6.14.4 The operational projects included within Table 6.40 are included due to their completion/commissioning subsequent to the data collection process for VE and as such not included within the baseline characterisation. Operational aggregate licence areas identified in Table 6.40 are considered within this CEA as they are located within a distance of one spring tidal excursion ellipse from VE. Accordingly, it is therefore necessary to consider the potential for cumulative changes in SSC.

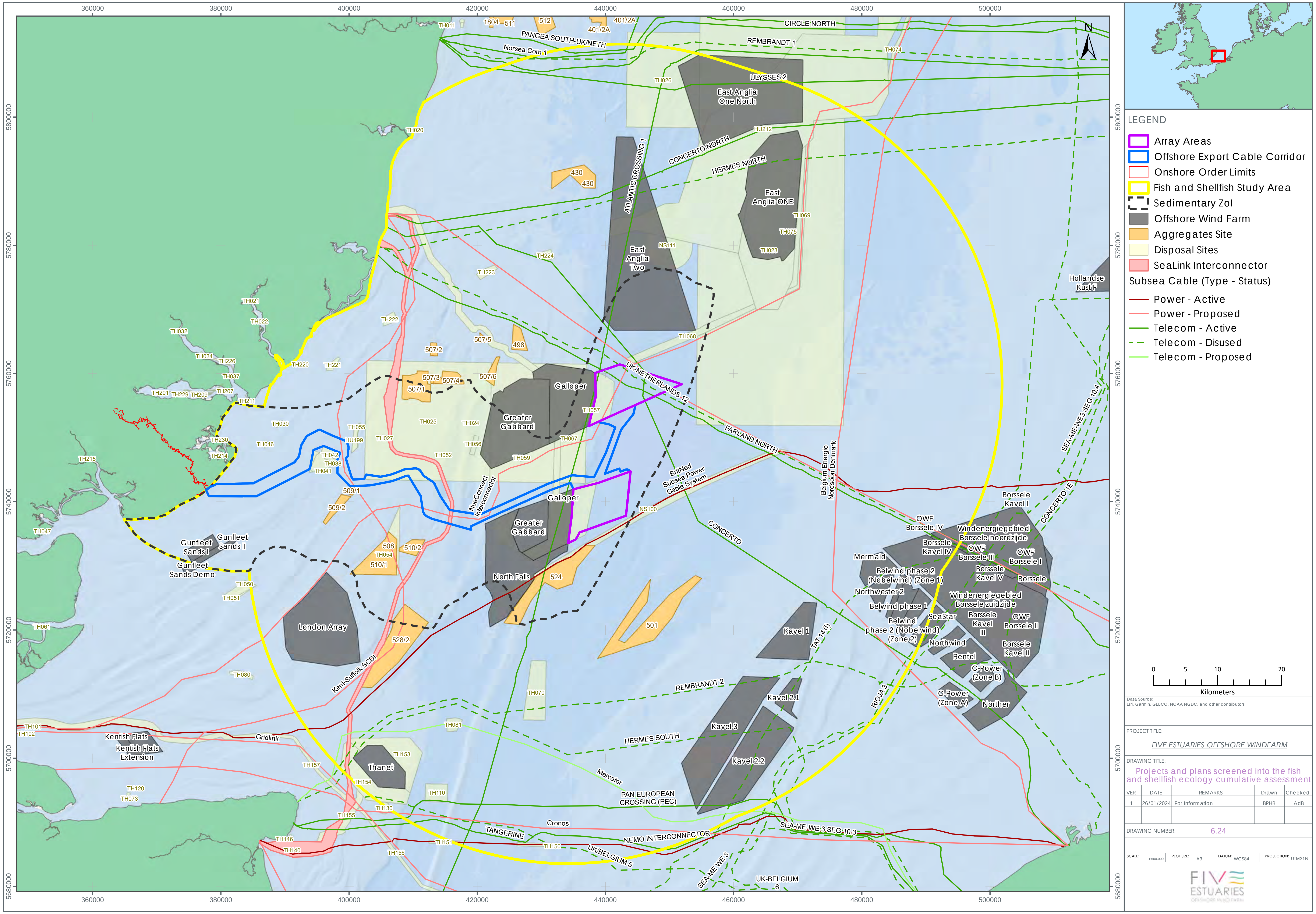
6.14.5 In line with PINS' advice, Table 6.39 provides criteria that may be used to indicate the certainty that can be applied to other existing development. The criteria are assigned in tiers which descend from Tier 1 (most certain) to Tier 3 (least certain) and reflect a diminishing degree of certainty which can be assigned to each development.

6.14.6 Note that Table 6.40 and Figure 6.24 only includes the projects screened into the assessment for fish and shellfish ecology based on the criteria outlined below. It should be noted that whilst Scroby Sands, Ijmuiden Ver and Dunkerque are included in Table 6.40, they are not included in Figure 6.24 due to the required scale of the map.

**Table 6.39: Description of Tiers of other developments considered for cumulative effect assessment.**

| Tiers | Development Stage |
|---|---|
| Tier 1 | Projects under construction. |
| | Permitted applications, whether under the Planning Act 2008 or other regimes, but not yet implemented. |
| | Submitted applications, whether under the Planning Act 2008 or other regimes, but not yet determined. |
| Tier 2 | Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has been submitted. |
| | Projects under the Planning Act 2008 where a PEIR has been submitted for consultation. |

| Tiers | Development Stage |
|---|---|
| **Tier 3** | Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has not been submitted. |
| | Identified in the relevant Development Plan (and emerging Development Plans with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited. |
| | Identified in other plans and programmes (as appropriate) which set the framework for future development consents/ approvals, where such development is reasonably likely to come forward. |




LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Order Limits
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Offshore Wind Farm
- Aggregates Site
- Disposal Sites
- SeaLink Interconnector

Subsea Cable (Type - Status)

- Power - Active
- Power - Proposed
- Telecom - Active
- Telecom - Disused
- Telecom - Proposed

0 5 10 20
Kilometers

Data Source:
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

*FIVE ESTUARIES OFFSHORE WINDFARM*

DRAWING TITLE:

Projects and plans screened into the fish and shellfish ecology cumulative assessment

| VER | DATE | REMARKS | Drawn | Checked |
|---|---|---|---|---|
| 1 | 26/01/2024 | For Information | BPHB | AdB |

DRAWING NUMBER: 6.24

SCALE: 1:500,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES

**Table 6.40: Projects considered within the fish and shellfish ecology cumulative effect assessment.**

| Development type | Project | Status | Data confidence assessment/ phase | Tier |
|---|---|---|---|---|
| OWF | North Falls | Pre-planning Application | High | Tier 2 |
| | East Anglia TWO | Consented | High | Tier 1 |
| | East Anglia ONE NORTH | Consented | High | Tier 1 |
| | Scroby Sands | Active/In Operation | High | Tier 1 |
| | IJmuiden Ver | Planned | Low | Tier 3 |
| | Dunkerque | Planned | Low | Tier 3 |
| Aggregates and Disposal | Tarmac Marine Ltd (509/1) | Operational | Medium | Tier 1 |
| | Tarmac Marine Ltd (509/2) | Operational | Medium | Tier 1 |
| | CEMEX UK Marine Ltd (510/2) | Operational | Medium | Tier 1 |
| | Tarmac Marine Ltd (509/3) | Operational | Medium | Tier 1 |
| | CEMEX UK Marine Ltd (510/1) | Operational | Medium | Tier 1 |
| | Britannia Aggregates Ltd (508) | Operational | Medium | Tier 1 |

| Development type | Project | Status | Data confidence assessment/ phase | Tier |
|---|---|---|---|---|
| | INNER GABBARD EAST (TH056) | Operational | Medium | Tier 1 |
| | DEME Building Materials Ltd (524) | Operational | Medium | Tier 1 |
| | CEMEX UK Marine Ltd (507/1) | Operational | Medium | Tier 1 |
| | CEMEX UK Marine Ltd (507/3) | Operational | Medium | Tier 1 |
| | CEMEX UK Marine Ltd (507/4) | Operational | Medium | Tier 1 |
| Dredge Spoil Disposal Site | Harwich Haven (TH027) | Operational | Medium | Tier 1 |
| | Inner Gabbard (TH052) | Operational | Medium | Tier 1 |
| | Inner Gabbard East (TH056) | Operational | Medium | Tier 1 |
| Interconnector Cable | EuroLink Multi-Purpose Interconnector (MPI) | Proposed | Low | Tier 3 |
| | NeuConnect | Consented | Medium | Tier 1 |
| | Nautilus MPI | Proposed | Medium | Tier 3 |
| | Sea Link | Proposed | Medium | Tier 3 |

6.14.7 It should be noted that operational projects such a Galloper and Greater Gabbard OWFs form part of the environmental baseline as they were operational at the point when site-specific data was collected across the VE array areas and offshore ECC. Therefore, they have not been considered within this cumulative assessment.

6.14.8 The cumulative MDS is described in Table 6.42 for each of the potential cumulative effects for this assessment. A description of the significance of cumulative effects upon fish and shellfish ecology receptors arising from each identified impact is provided in the sub-sections below. No additional potential fish and shellfish ecology impacts or receptors are identified than when considering VE cumulatively with the identified projects under the MDS.

6.14.9 Certain impacts assessed for VE alone are not considered in the cumulative assessment due to:

- The highly localised nature of the impacts (i.e., they occur entirely within the VE offshore ECC and array areas only);
- Management measures in place for VE will also be in place on other projects reducing the risk of impacts occurring; and/ or
- Where the potential magnitude of the impact from VE alone has been assessed as negligible.

6.14.10 The impacts excluded from the CEA, and the justification for their exclusion are tabulated below.

**Table 6.41: Impacts excluded from the CEA**

| Impact | Justification for exclusion from the CEA |
|---|---|
| **Construction phase** | |
| Impacts on fishing pressure due to displacement | The magnitude of the impact from VE alone has been assessed as **negligible**. (See Impact 4, Section 6.11) |
| Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities | Impacts arising from direct damage (e.g., crushing) and disturbance are anticipated to be highly localised, occurring entirely within the VE offshore ECC and array areas only (see Impact 5, Section 6.11) |
| Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors | Management measures in place for VE will also be in place on other projects reducing the risk of impacts occurring. These include the implementation of PEMP and MPCP (see Table 6.11) for VE. |

| Impact | Justification for exclusion from the CEA |
|---|---|
| Direct and indirect seabed disturbances leading to the release of sediment contaminants | The magnitude of the impact from VE alone has been assessed as **negligible**. (See Impact 3, Section 6.11) |
| **O&M Phase** | |
| Impacts on fishing pressure due to displacement | The magnitude of the impact from VE alone has been assessed as **negligible**. (See Impact 10, Section 6.12) |
| Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities; | Impacts arising from direct damage (e.g., crushing) and disturbance are anticipated to be highly localised, occurring entirely within the VE offshore ECC and array areas only (See Impact 14, Section 6.12). |
| Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors; | Management measures in place for VE will also be in place on other projects reducing the risk of impacts occurring. These include the implementation of a PEMP and MPCP (see Table 6.11) for VE. |
| Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection | Impacts arising from increased hard substrate and structural complexity are anticipated to be highly localised, occurring entirely within the VE offshore ECC and array areas only (See Impact 12, Section 6.12) |
| EMF effects generated by inter-array and export cables during operational phase. | Impacts arising from EMF are anticipated to be highly localised, occurring entirely within the VE offshore ECC and array areas only (See Impact 13, Section 6.12) |

6.14.11 The impacts that have been considered in the CEA are as follows:

- Construction phase:
  - Cumulative mortality, injury, behavioural changes, and auditory masking arising from noise and vibration;
  - Cumulative temporary increase in suspended sediment and sediment deposition;
  - Cumulative temporary habitat loss; and
  - Cumulative long-term or permanent habitat loss.

6.14.12 The cumulative MDS described in Table 6.42 have been selected as those having the potential to result in the greatest cumulative effect on an identified receptor group. The cumulative impacts presented and assessed in this section have been selected from the details provided in VE description for VE, as well as the information available on other projects and plans in order to inform a cumulative MDS. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within VE design envelope to that assessed here, be taken forward in the final design scheme.

**Table 6.42: Cumulative MDS.**

| Potential Effect | Scenario | Justification |
|---|---|---|
| Cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration | Tier 1:<br>Construction of East Anglia ONE North OWF.<br>Decommissioning of Scroby Sands OWF.<br>Tier 2:<br>Construction of North Falls OWF.<br>Tier 3:<br>Construction of IJmuiden Ver OWF.<br>Construction of Dunkerque OWF. | If these intermittent activities overlap temporally with either the construction or maintenance of VE, there is potential for cumulative effects from underwater noise to occur which may impact fish and shellfish populations. |
| Cumulative temporary increase in SSC and sediment deposition | Tier 1:<br>Operation of aggregate production areas including Tarmac Marine Ltd (509/1, 509/2, 509/3), CEMEX UK Marine Ltd (510/2, 507/1), Britannia Aggregates Ltd (508) and DEME Building Materials Ltd (524); | Identified sites are within a spring tidal excursion ellipse from the array areas and offshore ECC (secondary ZoI). If these intermittent activities overlap temporally with either the construction or maintenance of VE, there |

| Potential Effect | Scenario | Justification |
|---|---|---|
| | Operation of sea disposal sites Inner Gabbard (TH052), Inner Gabbard East (TH056) and Harwich Haven (TH027); and<br>Construction of NeuConnect Interconnector<br>Tier 2:<br>Construction of North Falls OWF<br>Construction and O&M of Sea Link interconnector cable<br>Tier 3:<br>Construction of Nautilus MPI<br>Construction of LionLink interconnector cable | is potential for cumulative SSC and sediment deposition to occur within the modelled plume footprints |
| Cumulative temporary habitat loss | Tier 1:<br>O&M of East Anglia Two OWF;<br>Operation of aggregate production areas including Tarmac Marine Ltd (509/1, 509/2, 509/3), CEMEX UK Marine Ltd (510/2, 507/1), Britannia Aggregates Ltd (508) and DEME Building Materials Ltd (524)<br>Construction and O&M of NeuConnect Interconnector<br>Tier 2:<br>Construction and O&M of OWF North Falls<br>Construction and O&M of Sea Link interconnector cable<br>Tier 3:<br>Construction and O&M Nautilus MPI<br>Construction and O&M of LionLink interconnector cable | If these intermittent activities overlap temporally with either the construction or maintenance of VE, there is potential for cumulative temporary habitat disturbance. |
| Long term or permanent habitat loss | Tier 1: | Maximum cumulative permanent habitat loss as |

| Potential Effect | Scenario | Justification |
|---|---|---|
| | O&M of East Anglia Two OWF;<br>O&M of NeuConnect Interconnector<br>Tier 2:<br>O&M of North Falls OWF<br>Construction and O&M of Sea Link interconnector cable<br>Tier 3:<br>O&M of Nautilus MPI<br>O&M of LionLink interconnector cable | a result of the presence of foundations, scour protection and cable protection is calculated within the fish and shellfish study area. There is no exact indication where cable and scour protection will occur, therefore as a very precautionary measure this assessment will assume the total for each project will occur in the fish and shellfish ecology study area. |

6.14.13 It should be noted that operational projects, within the ZoI, such as Galloper and Greater Gabbard offshore wind farms form part of the environmental baseline as they were operational at the point when site-specific data was collected across the VE array areas and offshore ECC. Therefore, they have not been considered within this cumulative assessment.

6.14.14 A description of the significance of cumulative effects upon fish and shellfish ecology arising from each identified impact is given below.

### IMPACT 24: CUMULATIVE MORTALITY, INJURY, BEHAVIOURAL CHANGES AND AUDITORY MASKING ARISING FROM NOISE AND VIBRATION

6.14.15 There is potential for cumulative mortality, injury, behavioural changes and auditory masking from noise and vibration as a result of construction and decommissioning activities associated with VE and other projects. For the purposes of this assessment, this additive impact has been assessed within 100 km of VE, which is considered a precautionary buffer upon which to screen in/out projects within the area.

6.14.16 The greatest risk of cumulative impacts of underwater noise on fish and shellfish species has been identified as being that produced by impact piling during the construction phase of other OWF sites within 100 km of VE, including the construction of East Anglia ONE North OWF, North Falls OWF, Dunkerque OWF and IJmuiden Ver OWF.

6.14.17 Injury or mortality of fish from piling noise and decommissioning activities would not be expected to occur cumulatively due to the small range within which potential injury effects would be expected (i.e. predicted to occur within a few km of the piling activities from each of the OWF projects) and the large distances between the offshore energy projects. Cumulative effects of underwater noise are therefore discussed in the context of behavioural effects, particularly on spawning or nursery habitats.

6.14.18 Piling operations will represent intermittent occurrences at these OWF sites with each individual piling event likely to be similar in duration to those at VE. For VE, the temporal MDS for piling duration is for the sequential installation of piled jacket foundations for up to 79 WTGs, and 2 OSPs for up to four hours per pile (Table 6.10)

6.14.19 It should be noted that the cumulative noise assessment has been based on information and assessments, where available, as presented in the respective Environmental Statements. Construction timescales are indicative and subject to change. The Environmental Statements for the IJmuiden Ver OWF and the Dunkerque OWF are not publicly available, therefore as a worst-case assumption for the projects, it is assumed that projects' parameters regarding underwater noise would be similar to those for VE.

6.14.20 The North Falls OWF PEIR has been submitted (RWE, 2023), therefore information on VE parameters regarding underwater have been accessed from the relevant PEIR chapters.

6.14.21 For the purposes of this assessment, the full length of the construction periods of the projects have been considered for potential cumulative effects due to a lack of data or information regarding the piling timescales for the East Anglia ONE North OWF, the IJmuiden Ver OWF, Dunkerque OWF and the North Falls OWF. Based on the MDS for piling duration at VE and the MDS piling durations for East Anglia ONE North OWF, IJmuiden Ver OWF, North Falls OWF (note the piling durations of VE has been used as proxy for IJmuiden Ver OWF and Dunkerque OWF), and the decommissioning of Scroby Sands (underwater noise impacts informed by construction MDS of construction phase of development), piling and decommissioning activities will occur over a maximum of 267.8 days (Table 6.43), equating to approximately 9.2% of the VE construction period (approximately eight years). This is considered to be highly precautionary, however, since the duration of piling events is likely to be shorter, in most cases, and simultaneous piling operations (between and within OWF sites) will also result in a reduction in the total piling duration. The construction periods for the East Anglia ONE North OWF (2026 – 2028), North Falls (2026-2029), IJmuiden Ver OWFs (2028-2029), Dunkerque OWF (2025-2027) and the decommissioning period of Scroby Sands (2031-2035) are also likely to include the combination of onshore and offshore construction periods and as such the projects may, in reality, not overlap temporally with the construction period of VE.

**Table 6.43: Cumulative piling durations for VE and other OWFs within a representative 100 km buffer of VE (where construction or decommissioning occurs concurrently).**

| Project | Maximum design scenario for piling duration | Source |
|---|---|---|
| **Tier 1 OWFs** | | |
| VE OWF | 1,360 hours | Volume 6, Part 2, Chapter 1: Offshore Project Description |
| East Anglia ONE North OWF | 844.8 hours | Total piling duration taken from ES (Royal Haskoning DHV, 2019) for all infrastructure assuming five hours per pin pile. |
| Scroby Sands OWF | 152 hours | Total duration taken from ES (PowerGen Renewables Offshore Ltd, 2001) for the piling of all infrastructure assuming four hours per pile (construction duration used as proxy for decommissioning). |
| **Tier 2 OWFs** | | |
| North Falls OWF | 1,350 hours | Total duration taken from PEIR (RWE, 2023) for the piling of all infrastructure assuming four and a half hours per pin pile. |
| **Tier 3 OWFs** | | |
| IJmuiden Ver OWF | 1,360 hours | Total duration taken from PEIR (RWE, 2023) for the piling of all infrastructure assuming four and half hours per pin pile. |
| Dunkerque OWF | 1,360 hours | 1,360 hours (52.6 days) Volume 6, Part 2, Chapter 1: Offshore Project Description (as |

| Project | Maximum design scenario for piling duration | Source |
|---|---|---|
| | | proxy for Dunkerque OWF ES). |
| **Total duration** | 6,426.8 hours | |

6.14.22 The following paragraphs describe the spatial extent of potential behavioural effects on fish and shellfish species. Each of the impact assessments consider the MDS for hammer energy and/or the largest pile diameter and therefore result in the greatest propagation ranges. It should be noted, however, that VE specific assessments may have used behavioural response criteria which differ from the approach used for VE and from the other projects in the cumulative assessment.

6.14.23 VE specific assessments were undertaken using the best scientific evidence available at the time that the assessments were drafted. However, more recent papers on the effects of underwater noise on fish and shellfish species have highlighted the lack of clear evidence to support setting thresholds for impacts on fish and shellfish receptors (Hawkins and Popper 2016; Popper *et al*. 2014). These papers have highlighted some of the shortcomings of historic impact assessments, including the use of broad criteria for injury and behavioural effects based on limited studies. As such, it is not appropriate to make direct comparisons between the behavioural response ranges across projects, however the following paragraphs do give an indication of the extents of behavioural responses from fish and shellfish to support this cumulative assessment.

6.14.24 The East Anglia ONE North OWF (Royal Haskoning DHV, 2019) assessed the MDS for noise impacts, of piling of pin piles using hammer energies of up to 2,400 kJ. This assessment assumed a maximum of 268 WTGs across the site and predicted behavioural effects up to 29 km from the piling locations. The assessment predicted minor adverse effects on all fish and shellfish receptors.

6.14.25 The North Falls OWF PEIR assessed the MDS for noise impacts, arising from the piling of 74 monopiles with hammer energies up to 6,000 kJ (for stationary receptors), and the piling of 300 pin piles using hammer energies up to 3,000 kJ. The PEIR concluded moderate (significant) effects on the Downs herring spawning stock from underwater noise impacts (RWE, 2023).

6.14.26 The Scroby Sands OWF Environmental Statement concluded no detrimental effects on fish receptors from all phases of VE (PowerGen Renewables Offshore Ltd, 2001).

6.14.27 There is currently limited detail on the Dunkerque OWF and the IJmuiden Ver OWF, therefore it is not possible to undertake detailed assessments of the significance of effect. However, given the intermittent nature of piling, it is unlikely that there will be a temporal overlap resulting in significant effects on fish and shellfish receptors.

6.14.28 The cumulative impact of underwater noise on fish and shellfish is predicted to be of regional spatial extent, medium term duration (i.e. cumulatively over approximately seven years), intermittent and reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

6.14.29 Sensitivities of fish and shellfish receptors to underwater noise are fully detailed in Table 6.20, Table 6.21 and Table 6.22. Fish injury as a result of piling noise would only be expected in the immediate vicinity of piling operations, and the area within which effects on fish larvae would be expected is similarly small, though it is unclear whether effects on fish larvae would include injury or mortality. Effects on shellfish species are also predicted to be limited as these species are less sensitive to noise than fish species or would only be affected at ranges much less than those predicted for fish.

6.14.30 Behavioural effects on fish species as a result of piling noise are predicted to be dependent on the nature of the receptors, with larger impact ranges predicted for pelagic fish than for demersal fish species. The predicted behavioural response may be sufficient to result in temporary avoidance of these areas by these species, with some temporary redistribution of fish in the wider area between the affected areas. Between piling events, fish may resume normal behaviour and distribution, as evidenced by work of McCauley *et al*., (2000) which showed that fish returned to normal behavioural patterns within 14 to 30 minutes after the cessation of seismic airgun firing. However, there are some uncertainties over the response of fish to intermittent piling over a prolonged period and the extent that behavioural reactions will cause a negative effect in individuals.

6.14.31 The proportions of fish spawning and nursery habitats predicted to be affected by underwater noise from piling operations are expected to be small, particularly in the context of available spawning and nursery habitats within the southern North Sea (particularly for pelagic spawning species). The maximum sensitivity of fish receptors to underwater noise is considered to be **low** to **medium**.

6.14.32 Shellfish are considered to be less sensitive to noise than fish as they do not possess a swim bladder, however they do show some sensitivity to increased particle motion (Roberts *et al*., 2016), with studies showing behavioural changes in shellfish in response to increased noise levels (Samson *et al*., 2016; Spiga *et al*., 2016). As a result of this, the sensitivity of shellfish is considered to be low.

6.14.33 The impact of cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration is considered to be of **low adverse** magnitude, and the maximum sensitivity of receptors affected is considered to be **high** for fish and shellfish species. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 25: CUMULATIVE TEMPORARY INCREASE IN SSC AND SEDIMENT DEPOSITION

6.14.34 There is potential for cumulative increases in SSC and associated sediment deposition as a result of construction activities associated with VE and the projects identified in Table 6.40. For the purposes of this assessment, this additive impact has been assessed from projects that fall within the fish and shellfish ecology sedimentary ZoI (Figure 6.2), which is defined based on the expected maximum distance that sediments from within the VE array areas and offshore ECC might be transported on a single mean spring tide, in the flood and/or ebb direction. Table 6.40 identifies the projects that have the potential to contribute to cumulative temporary SSC's and deposition.

6.14.35 The SSC plumes generated during the construction (and operation) of VE are not predicted to reach the majority of the aggregate and disposal sites in any significant concentrations. The zone of measurable SSC increases, and measurable deposition is within 500 m of the construction impact. Therefore, the only aggregate license area that will overlap in terms of potential significant impact is Tarmac Marine Ltd License Area 509/1. This site lies 100 m from the VE offshore ECC, however is still located outside the 0-50 m zone of highest SSC increase and greatest likely thickness of deposition. Furthermore, Tarmac Marine Ltd have confirmed that they do not intend to take this site forward (personal communication, May 2021). Therefore, on account of the distance of the majority of these impacts from the zones of highest impact and the fact that they are intermittent in nature, the magnitude is expected to **low**.

6.14.36 The consented NeuConnect Interconnector is proposed to cross with approximately 78 km of the VE fish and shellfish ecology sedimentary ZoI. Construction is expected to occur in 2027, so there will be one year of construction overlap with VE construction. The installation of the NeuConnect Interconnector and any subsequent increases in SSC and sediment deposition that would have the potential to pose a significant smothering impact to fish and shellfish ecology receptors is expected to short-term and localised to the development area. Additionally given the relatively limited overlap with the fish and shellfish sedimentary ZoI compared to the interconnector's overall extent (28%), significant cumulative effects are not anticipated.

6.14.37 The magnitude of impacts from the Tier 1 projects identified is therefore considered to be worst-case **low**.

6.14.38 The construction of Tier 2 project 'North Falls OWF' is anticipated to overlap with the construction of VE, with construction occurring from 2026 to 2029, so there will be three years of construction overlap with VE. Whilst there is a temporal overlap, it is considered unlikely that plumes from adjacent wind farms would be unlikely to overlap due to the short-term and highly localised nature of plumes arising from construction works.

6.14.39 The Tier 2 project 'Sea Link' Interconnector and the Tier 3 projects 'Nautilus' and 'LionLink' MPIs are predicted to overlap their construction impacts, with VE construction, which is predicted to increase SSC and deposition within the wider fish and shellfish ecology study area. It is not known what volumes of sediment are likely to be displaced as the project's haven't submitted their Environmental

Assessments. However, we do know that the projects will cause intermittent disturbances over the construction period and that spatial overlap resulting in a heavy level (5 - 30 cm) of deposition is unlikely (as this is only predicted to occur within 0 to 50 m of impact, based on the results presented in Volume 6, Part 5, Annex 2.3: Physical Processes Technical Assessment.

6.14.40 The cumulative impacts of increased SSC and sediment deposition are deemed to be **low adverse** magnitude, indicating that the potential is for localised disturbance that does not threaten the permanent viability of the resource.

6.14.41 As presented in Table 6.27, the maximum sensitivity of the fish and shellfish receptors within the region to increases in SSC and sediment deposition is **medium**.

6.14.42 The impact of cumulative temporary increases in SSC and deposition is considered to be of **low adverse** magnitude, and the maximum sensitivity of receptors affected is considered to be **medium** for fish and shellfish species. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## IMPACT 26: CUMULATIVE TEMPORARY HABITAT LOSS

6.14.43 There is potential for cumulative temporary habitat loss as a result of both the construction and maintenance activities associated with VE and the Tier 1, 2 and 3 projects identified in Table 6.40. For the purposes of this assessment, this additive impact has been assessed from projects that fall within the fish and shellfish ecology secondary ZoI.

6.14.44 The VE array areas and offshore ECC do not overlap with any of the aggregate sites. The impacts from both the construction and operation of VE and from aggregate extraction activities are predicted to be of local spatial extent, short-term, intermittent, and reversible. The same is true of the operation and maintenance activities associated with East Anglia Two, where any operation and maintenance associated with jack-up operations and inter-array cable maintenance activities will be restricted to within the footprint of the project area, which does not directly overlap with the VE array areas or offshore ECC.

6.14.45 The consented NeuConnect Interconnector is proposed to cross with 78 km of the VE fish and shellfish ecology secondary ZoI. Construction is expected to occur in 2027, so there will be one year of construction overlap with VE construction. Operation and maintenance of NeuConnect Interconnector will also overlap with VE construction. The installation of the NeuConnect Interconnector and any subsequent operation and maintenance activities are expected to short-term and localised to the site. Additionally given the relatively limited overlap with the secondary ZoI compared to the interconnector’s overall GB extent (28%), no significant cumulative effects are predicted with the construction of VE.

6.14.46 The magnitude of impacts from the Tier 1 projects identified is therefore considered to be worst-case **low adverse**.

6.14.47 There is no direct spatial overlap of North Falls OWF with the VE array areas, however the project overlaps with the offshore ECC and falls within the fish and shellfish ecology sedimentary ZoI (Figure 6.18). Physical disturbance from the installation of the North Falls export cable corridor is anticipated to occur at discrete locations (i.e. limited to the immediate vicinity of the works) at any given time, due to the intermitted and localised nature of the works (RWE, 2023). Therefore, no significant cumulative effects are predicted with the construction of VE.

6.14.48 There is no information in the public domain regarding the defined area for total temporary habitat disturbance, however based on OWF's of a similar size it is known that both the construction and operation and maintenance activities will be short-term, intermittent and localised to the site and therefore any cumulative impacts are expected to be minimal. Taking this into consideration, there are not predicted to be any significant cumulative impacts from the construction or operation of North Falls.

6.14.49 The Tier 2 project 'Sea Link interconnector cable' is a proposed offshore HVDC link between Suffolk and Kent, the purpose of which is to take the power brought in by East Anglia One North, East Anglia Two, Lionlink and Sizewell from Suffolk down to Kent to distribute within the Thames Valley where it is needed. There is currently limited detail on the project and therefore it is not possible to make a detailed assessment of the significance of effect, however it is predicted that any temporary habitat disturbance from the construction, operation and maintenance will be short term and localised to the site. It is not anticipated that any effects, once qualified, would result in a significant impact in EIA terms.

6.14.50 The magnitude of impacts from this Tier 2 project is deemed at worst-case **low**.

6.14.51 The Tier 3 project 'Nautilus MPI' is a proposed interconnector at the pre-scoping stage of consenting. The interconnector would be a subsea electricity cable that connects Great Britain to neighbouring energy markets in Belgium. This project forms part of the Offshore transmission network review (OTNR), which investigates the way that the offshore transmission network is designed and delivered, consistent with the ambition to deliver net zero emissions by 2050. There is currently limited detail on the project and therefore it is not possible to make a detailed assessment of the significance of effect, however it is predicted that any temporary habitat disturbance from the construction, operation and maintenance of Nautilus MPI is minimal, short term and localised to the site. Given the overlap of the interconnector with the secondary ZoI (8.5%) compared to its overall extent (approximately 200 km), it is not anticipated that any effects, if consented, would result in a significant impact in EIA terms.

6.14.52 The Tier 3 project 'LionLink' is another proposed MPI project also at the pre-scoping stage of consenting. The project would deliver a new electricity link between Great Britain to the Netherlands. While limited information is available at this time, it is expected that if consented, LionLink and Nautilus MPI construction activities will overlap with VE construction.

6.14.53 As presented in Table 6.33, the maximum sensitivity of the fish and shellfish receptors within the region to temporary habitat loss is **medium**.

6.14.54 Cumulative effects can also be considered in terms of duration of exposure from multiple projects which do not overlap but happen consecutively. As the effects from the projects will be short-lived, and due to the resilience of the receptors to this type of impact, concurrent cumulative effects are not expected.

6.14.55 Overall, it is predicted that the cumulative impact of temporary habitat disturbance on fish and shellfish receptors is considered to be of **low adverse** magnitude, and the sensitivity of receptors affected is considered to be worst-case **medium**. The significance of the residual cumulative effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

### IMPACT 27: CUMULATIVE LONG TERM OR PERMANENT HABITAT LOSS

6.14.56 Cumulative long term or permanent habitat loss is predicted to occur because of the presence of VE infrastructure and projects identified in Table 6.40. The Tier 1 project East Anglia Two OWF and transmission asset is expected to contribute to long term or permanent habitat loss from the physical presence of foundations, scour and cable protection. East Anglia Two array area overlaps with the fish and shellfish ecology study area and the total long term or permanent habitat loss associated with the array assets is 1.91 km$^2$, the transmission assets do not overlap with the study area.

6.14.57 The NeuConnect Interconnector is anticipated to have cable protection associated with the route, where the target burial depth cannot be achieved. While the cumulative impact of permanent habitat loss will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures, the footprint of the area affected is highly localised. It is expected that the impacts are reversible following removal of any of the hard substrate, where this might occur however is less certain. As spawning substrates are common and widespread throughout the wider region, the loss of these habitats is not anticipated to have a significant effect on fish and shellfish populations. The magnitude of loss for Tier 1 projects is therefore assessed as **negligible**.

6.14.58 The Tier 2 project North Falls OWF has the potential to create a cumulative permanent habitat loss with VE. The loss of habitat from introduction of the North Falls OWF export cable will be permanent throughout the expected design life of the project. However, the loss of habitat will be localised to areas where project infrastructure is located. Therefore considering the widespread nature of fish and shellfish habitats across the region, the loss of these habitats is not anticipated to have a significant effect on fish and shellfish populations.

6.14.59 The Tier 2 Project 'Sea Link' and Tier 3 projects 'Nautilus' and 'LionLink' MPIs are anticipated to have some cable protection associated with the route, however there is currently limited information on this. The footprint of any cable protection is expected to be limited in extent and highly localised. The magnitude of loss for Tier 2 and 3 projects is therefore currently assessed as **negligible**.

6.14.60 While the cumulative impact of permanent habitat loss will be locally significant and comprise a permanent change in seabed habitat within the footprint of the structures, the footprint of the area affected is highly localised. It is expected that the impacts are reversible following removal of any of the hard substrate, where this might occur however is less certain. As spawning substrates are common and widespread throughout the wider region, the loss of these habitats is not anticipated to have a significant effect on fish and shellfish populations.

6.14.61 As presented in Table 6.35, the maximum sensitivity of the fish and shellfish receptors within the region to long term or permanent habitat loss is **medium**.

6.14.62 The impact of cumulative long term or permanent habitat loss is considered to be of **negligible** magnitude, and the maximum sensitivity of receptors affected is considered to be **medium** for fish and shellfish species. The significance of the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

## 6.15 CLIMATE CHANGE

6.15.1 Climate change has the potential to affect the extent, distribution and abundance of fish and shellfish ecology receptors (See section 6.7; 6.7.33 - 6.7.40). This section assesses the following aspects:

- The effect of climate change on the local area in which the proposed development will take place; and
- The likely impacts of climate change and the project in-combination on the receiving environment.

6.15.2 The information provided in this section will be drawn upon and summarised in Volume 6, Part 4, Chapter 1: Climate change. As outlined in Volume 6, Part 4, Chapter 1: Climate Change, the operational phase of VE would enable the use of renewable electricity which would result in a positive greenhouse gas impact, resulting in a significant beneficial effect.

### EFFECT OF CLIMATE CHANGE ON THE LOCAL ENVIRONMENT

6.15.3 The following effects of climate change have the potential to affect fish and shellfish ecology receptors:

- Increased sea temperatures and/or changes to PH levels: increased temperatures and acidification could lead to changes in population distribution. Potential loss of marine habitats and species:
  - Limited effects anticipated on mobile species, as distributions of such species are also expected to move with temperature ranges and shifts in food availability.
  - Effects associated with substrate dependent species (e.g. herring and sandeel) as these species may be unable to adapt their distribution to compensate for warming sea temperatures. Impacts to key prey species may lead to bottom-up effects of climate change on marine food webs.

- Reduced PH levels due to acidification may impact calcifying species such as shellfish. Population level effects may lead to bottom-up effects of climate change on marine food webs.

- Sea level rise (coastal flooding), storminess and wave energy may affect benthic habitats relied on by fish and shellfish (Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology). Sea level rise has the potential to affect habitat availability for some intertidal species and intertidal habitats. This may lead to impacts on species who rely on brackish water for survival.

#### EFFECT OF CLIMATE CHANGE AND THE PROJECT ON THE LOCAL ENVIRONMENT

6.15.4 The project is not predicted to contribute to the impacts of climate change in the local area to any significant extent.

### 6.16 INTER-RELATIONSHIPS

6.16.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, O&M and decommissioning); to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g., subsea noise effects from piling, operational WTGs, vessels and decommissioning); and
- Receptor-led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects, or incorporate longer term effects.

6.16.2 A description of the likely inter-related effects arising from VE on fish and shellfish ecology is provided in Volume 6, Part 4, Chapter 3: Inter-Relationships, with a summary of assessed inter-relationships provided below.

- Benthic Ecology – impacts to benthic ecology receptors may affect prey resource for fish and shellfish ecology receptors;
- Marine Water and Sediment Quality – impacts on water quality (i.e., resuspension of contaminants); Commercial fisheries – changes to fishing intensity or gear types may affect fish and shellfish ecology receptors;
- Marine Mammal Ecology – impacts to fish and shellfish ecology receptors may affect prey resource for marine mammal receptors; and
- Offshore Ornithology - impacts to fish and shellfish ecology receptors may affect prey resource for ornithological receptors.

### 6.17 TRANSBOUNDARY EFFECTS

6.17.1 No transboundary impacts are predicted to result from the construction, O&M and decommissioning phases of VE in terms of fish and shellfish receptors. In line with the transboundary screening (Volume 6, Part 1, Annex 3.2: Transboundary Screening), no potentially significant transboundary effects are predicted for fish and shellfish receptors and therefore a transboundary effects assessment is not considered necessary in this chapter.

## 6.18 SUMMARY OF EFFECTS

6.18.1 This chapter has assessed the potential effects on fish and shellfish ecology receptors arising from VE. The range of potential impacts and associated effects considered has been informed by scoping responses, as well as reference to existing policy and guidance. The impacts considered include those brought about directly (e.g., by the presence of infrastructure at the seabed), as well as indirectly (e.g., the release of sediment contaminants from seabed disturbances). Potential impacts considered in this chapter, alongside any mitigation and residual effects are listed below in Table 6.44.

6.18.2 The impacts on relevant receptors from all stages of the project were assessed, including impacts from habitat loss, underwater noise, increased SSC and deposition and release of sediment contaminants.

6.18.3 Mortality, injury, behavioural impacts and auditory masking from underwater noise and vibration form the construction of VE have the potential for a significant effect without the implementation of mitigation, in EIA terms, during the construction phase of development. A seasonal piling restriction during the peak herring spawning period (6th November to 1$^{st}$ January) has therefore been proposed (Table 6.12).

6.18.4 In addition, increased SSC and sediment deposition from the construction of VE also has the potential to have a significant effect on the Downs stock herring spawning habitats. A sediment disposal restriction has been proposed, whereby dredge material from the northern array area will not be disposed of within the southern array area, to ensure that herring spawning habitat characteristics are maintained in the southern array area (Table 6.12).

6.18.5 All other impacts assessed were found to have either **negligible**, or **minor** effects on fish or shellfish receptors within the study area (i.e., not significant in EIA terms).

**Table 6.44: Summary of effects on fish and shellfish receptors**

| Description of Impact | | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|---|
| **Construction** | | | | |
| Impact 1: Mortality, injury, behavioural impacts and auditory masking from underwater noise and vibration | Mortality and potential mortal injury | **Array Areas:** Minor Adverse significance of effect<br>**Offshore ECC:** Minor Adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| | Recoverable Injury | **Array Areas:** Minor to Adverse significance of effect<br>**Offshore ECC:** Minor Adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| | TTS | **Array Areas:** Minor Adverse significance of effect<br>**Offshore ECC:** Minor Adverse significance of effect | No mitigation required. | No significant adverse residual effects |

| Description of Impact | | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|---|
| | Behavioural effects | **Array Areas:** Minor to Moderate Adverse significance of effect<br>**Offshore ECC:** Minor Adverse significance of effect | Seasonal piling restriction (Table 6.12) | No significant adverse residual effects, following the implementation of mitigation. |
| Impact 2: Temporary increase in SSC and sediment deposition | | **Array areas:** Minor to Moderate adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | Dredge disposal restriction (Table 6.12) | No significant adverse residual effects, following the implementation of mitigation. |
| Impact 3: Direct and indirect seabed disturbances leading to release of sediment contaminants | | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 4: Impacts on fishing pressure due to displacement | | **Array areas:** Negligible significance of effect<br>**Offshore ECC:** Negligible significance of effect | No mitigation required. | No significant adverse residual effects |

| Description of Impact | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|
| Impact 5: Direct damage (e.g. crushing) and disturbance to demersal and pelagic fish and shellfish species arising from construction activities | **Array areas:** Negligible to minor adverse significance of effect<br>**Offshore ECC:** Negligible to minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 6: Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 7: Temporary habitat loss/disturbance from construction operations including foundation installation and cable laying operations | **Array areas:** Negligible to minor adverse significance of effect<br>**Offshore ECC:** Negligible to minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| **Operation and Maintenance** | | | |

| Description of Impact | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|
| Impact 8: Underwater noise as a result of operational WTGs and maintenance vessel traffic resulting in potential effects on fish and shellfish receptors | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 9: Temporary increase in SSC and deposition arising from operation and maintenance activities | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 10: Impacts on fishing pressure due to displacement | **Array areas:** Negligible significance of effect<br>**Offshore ECC:** Negligible significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 11: Long term or permanent loss of habitat due to the presence of WTGs foundations, scour protection and cable protection | **Array areas** Negligible to minor adverse significance of effect<br>**Offshore ECC:** Negligible to minor | No mitigation required. | No significant adverse residual effects |

| Description of Impact | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|
| | adverse significance of effect | | |
| Impact 12: Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection | **Array areas:** Negligible to minor adverse significance of effect<br>**Offshore ECC:** Negligible to minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 13: EMF effects arising from cables during operational phase | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 14: Direct damage (e.g., crushing) and disturbance to mobile, demersal and pelagic fish and shellfish species arising from operation and maintenance activities. | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |

| Description of Impact | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|
| Impact 15: Accidental pollution events during the operation and maintenance phase resulting in potential effects on fish and shellfish receptors | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 16: Temporary habitat loss | **Array areas:** Minor adverse significance of effect<br>**Offshore ECC:** Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| **Decommissioning** | | | |
| Impact 17: Mortality, injury, behavioural impacts and auditory masking from underwater noise and vibration | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 18: Temporary increase in SSC and sediment deposition | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 19: Direct and indirect seabed disturbances leading to release of sediment contaminants | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |

| Description of Impact | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|
| Impact 20: Impacts on fishing pressure due to displacement | Negligible significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 21: Direct damage (e.g. crushing) and disturbance to demersal and pelagic fish and shellfish species arising from construction activities | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 22: Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 23: Temporary habitat loss/disturbance | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| **Cumulative effects** | | | |
| Impact 24: Cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 25: Temporary increase in suspended sediment and sediment deposition | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |
| Impact 26: Cumulative temporary permanent habitat loss | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |

| Description of Impact | Significance of Effect | Additional mitigation measures | Residual significance of effect |
|---|---|---|---|
| Impact 27: Cumulative long term or permanent habitat loss | Minor adverse significance of effect | No mitigation required. | No significant adverse residual effects |

## 6.19 REFERENCES


Alheit, J. and Hagen E. (1997), 'Long-term climate forcing of European spawning herring and sardine populations', Fisheries Oceanography, 6: 130-139.

Andersson, M.H. (2011). Offshore Wind Farms - Ecological Effects of Noise and Habitat Alteration on Fish. PhD Thesis, Department of Zoology, Stockholm University, pp.1–48.

André, M., Solé, M., Lenoir, M., Durfort, M., Quero, C., Mas, A., Lombarte, A., van der Schaar, M., Lopéz-Bejar, M., Morell, M., Zaugg, S. and Houégnigan, L. (2011). Low frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment, 9(9), pp.489–493.

BEIS (2016), 'UK Offshore Energy Strategic Environmental Assessment 3 (OESEA 3) Appendix 1a.4 – Fish and Shellfish', March 2016.

BEIS (2021a). Draft revised Overarching NPS EN-1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015233/en-1-draft-for-consultation.pdf. [Accessed November 2022].

BEIS (2021b). Draft National Policy Statement for Renewable Energy Infrastructure (EN-3). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015236/en-3-draft-for-consultation.pdf. [Accessed November 2022].

Beggs, S. E., Cardinale, M., Gowen, R. J. and Bartolino, V. (2013), 'Linking cod (*Gadus morhua*) and climate: investigating variability in Irish Sea cod recruitment', Fisheries Oceanography, 23: 54- 64.

Betke, K., Schultz-von Glahn, M., and Matuschek R. (2004), 'Underwater noise emissions from offshore wind WTGs', Proc CFA/DAGA, 2004.

Bochert, R. and Zettlerm M. L. (2004), 'Long-term exposure of several marine benthic animals to static magnetic fields', Bioelectromagnetics, 25: 498- 502.

Boyle, G. & New, P. 2018. ORJIP Impacts from Piling on Fish at Offshore Wind Sites: Collating Population Information, Gap Analysis and Appraisal of Mitigation Options. Final report – June 2018. The Carbon Trust. United Kingdom. 247 pp.

Brown & May Marine Ltd. (2007). Herring spawning survey of Thanet Offshore Wind Farm. Report for Thanet Offshore Wind Ltd.

Brown & May Marine Ltd. (2008). Herring spawning survey of Thanet Offshore Wind Farm. Report for Thanet Offshore Wind Ltd

Bruintjes, R., Simpson, S.D., Harding, H., Bunce, T., Benson, T., Rossington, K. and Jones, D. (2016). The impact of experimental impact pile driving on oxygen uptake in black seabream and plaice. In Proceedings of Meetings on Acoustics 4ENAL (Vol. 27, No. 1, p. 010042). Acoustical Society of America.

Bunn, N. A., Fox, C. J. and Webb, T. (2000), 'A Literature Review of Studies on Fish Egg Mortality: Implications for the Estimation of Spawning Stock Biomass by the Annual Egg Production Method', Cefas Science Series Technical Report No. 111, pp 37.

Burt *et al.* (2019), 'Young Fish Survey Data 1981 to 2010'. Cefas, UK V1. doi: https://doi.org/10.14466/CefasDataHub.73

Byrne Ó Cléirigh Ltd, Ecological Consultancy Services Ltd (EcoServe) and School of Ocean and Earth Sciences, University of Southampton (2000), 'Assessment of Impact of Offshore Wind Energy Structures on the Marine Environment'. Prepared for the Marine Institute.

Capuzzo, Elisa, Christopher P. Lynam, Jon Barry, David Stephens, Rodney M. Forster, Naomi Greenwood, Abigail McQuatters-Gollop, Tiago Silva, Sonja M. van Leeuwen, and Georg H. Engelhard. A Decline in Primary Production in the North Sea over 25 Years, Associated with Reductions in Zooplankton Abundance and Fish Stock Recruitment. Global Change Biology 24, 1:352–64.

Cheong, S-H., Wang, L., Lepper, P. and Robinson, S. (2020), Characterisation of Acoustic Fields Generated by UXO Removal. Phase 2. NPL REPORT AC 19.

CMACS (2012). East Anglia One Offshore Wind Farm: Electromagnetic Field Environmental Appraisal. Assessment of EMF on sub tidal marine ecology. APPENDIX 9.2 Electromagnetic Field Environmental Appraisal of East Anglia Three ES.

Collett, A.G., Mason, T.I., Cheesman, S. and Bird, H. (2012). Measurement and assessment of underwater noise during impact piling operations of the Met Mast Foundation at Rampion wind farm. Subacoustech report E356R0204. Southampton; Subacoustech.

Cooper, K. and Barry, J. (2017). RSMP Baseline Dataset. Cefas, UK. V1. Available at: https://doi.org/10.14466/CefasDataHub.34 [Accessed September 2021].

Coull, K.A. Johnstone, R. and Rogers, S.I. (1998) Fisheries Sensitivity Maps in British Waters Published and distributed by UKOOA Ltd. Aberdeen, 63 pp. Dana Petroleum (2018). Platypus Development Environmental Statement (D/4229/2018).

Dahl, P. H., Jenkins, A. K., Casper, B., Kotecki, S. E., Bowman, V., Boerger, C., Dall'Osto, D. R., Babina, M. A., and Popper, A. N. (2020). "Physical effects of sound exposure from underwater explosions on Pacific sardines (*Sardinops sagax*)," J. Acoust. Soc. Am. 147(4), 2383–2395.

DESNZ (2023a), Overarching National Policy Statement for Energy (EN-1). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-forenergy-en1.pdf [Accessed: November 2023].

DESNZ (2023b), National Policy Statement for Renewable Energy Infrastructure (EN-3). https://assets.publishing.service.gov.uk/government/uploads/system/ Page 249 of 256 uploads/attachment_data/file/37048/1940-nps-renewable-energyen3.pdf [Accessed: November 2023].

DESNZ (2023c). National Policy Statement for Electricity Networks Infrastructure EN-5. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37050/1942-national-policy-statementelectricity-networks.pdf [Accessed: November 2023]

DECC (2016) UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3) Appendix 1a.4 Fish and Shellfish.

Defra (2014) East Inshore and East Offshore Marine Plans https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/312496/east-plan.pdf [Accessed: December 2022]

Dickey-Collas M., Bolle L. J., van Beek J. K. L., Erftemeijer P. L. A. (2009) Variability in transport of fish eggs and larvae. II. The effects of hydrodynamics on the transport of Downs herring larvae, Marine Ecology Progress Series, 2009, vol. 390 (pg. 183-194)10.3354/meps08172

Dyer R (2019). Oyster Survey Report 2019: Native Oysters (*Ostrea edulis*) in the Blackwater, Crouch, Roach and Colne Estuaries Marine Conservation Zone. Kent and Essex Inshore Fisheries and Conservation Authority.

Edwards, B., Brooker, A., Workman, R., Parvin, S. J. and Nedwell, J. R. (2007) Subsea operational noise assessment at the Barrow Offshore Wind Farm site. Subacoustech Report No. 753R0109.

EIFCA (2020) Whelk Technical Summary Report – Review of whelk permit conditions. 26pp.

Ellis, J.R., Milligan, S.P. Readdy, L. Taylor, N. and Brown, M.J. (2012), 'Spawning and nursery grounds of selected fish species in UK waters'. Cefas Scientific Series Technical Report 147.

EUSeaMap, (2021) Broadscale Marine Habitats Map.

Everitt, N. (2008). Behavioural responses of the shore crab, *Carcinus maenas*, to magnetic fields. MSc Thesis, University of Newcastle-upon-Tyne: 94pp.

Fewtrell, J.L. and McCauley, R.D. (2012). Impact of air gun noise on the behaviour of marine fish and squid. Marine Pollution Bulletin, 64(5), pp.984–993.

Five Estuaries Wind Farm Ltd (2021) Five estuaries offshore windfarm environmental impact assessment scoping report.

Fugro, (2021). NF PSA sediment characteristics North Falls Offshore Site pre-construction survey data.

Fugro, (2022a). Fugro - WPM1 - Main Array – Benthic Ecology Monitoring Report

Fugro, (2022b). Fugro – WPM2, WPM3 & WPM4 – ECR & Intertidal – Benthic Ecology Monitoring Report

Frederiksen, M. Edwards, M. Richardson, A.J. Halliday, N.C. and Wanless, S. (2006) From plankton to top predators: bottom-up control of a marine food web across four trophic levels. Journal of Animal Ecology 75: 1259-1268.

Gill, A. B. & Taylor, H (2001). The potential effects of electromagnetic fields generated by cabling between offshore wind WTGs upon elasmobranch fishes. 488. 2001b. Countryside Council for Wales Contract Science Report.

Gill, A. B. and A. A. Kimber. (2005). The potential for cooperative management of elasmobranchs and offshore renewable energy Page 250 of 256 development in UK waters. Journal of the Marine Biological Association of the United Kingdom 85:1075-1081.

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V. (2009). COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-Sensitive Fish Response to EM Emissions from Sub-Sea Electricity Cables of the Type used by the Offshore Renewable Energy Industry. COWRIE-EMF-1-06.

Gill, A.B., and Bartlett, M. (2010). Literature Review on the Potential Effects of Electromagnetic Fields and Subsea Noise from Marine Renewable Energy Developments on Atlantic Salmon, Sea Trout and European Eel. Scottish Natural Heritage, Commissioned Report No. 401. (Sutton and Boyd, 2009).

Götz, T., Hastie, G., Hatch, L.T., Raustein, O., Southall, B.L., Tasker, M., Thomsen, F., Campbell, J. and Fredheim, B. (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. OSPAR Biodiversity Series, 441, pp.1–134.

Grant, J., Enright, C.T. & Griswold, A., 1990. Resuspension and growth of *Ostrea edulis*: a field experiment. Maine Biology, 104, 51-59.

Hall S. , Robertson M. , Basford D. , Fryer R. (1993). Pit-digging by the crab *Cancer pagurus*: a test for long-term, large-scale effects on infaunal community structure. Journal of Animal Ecology, 62: 59–66.

Hart, P.J.B. Blyth, R.E. Kaiser, M.J. and Jones, G.E. (2004) Sustainable Exploitation with Minimal Conflict: Is It Possible? In: Who owns the sea? (Who owns the sea workshop proceedings, Tjarno, Sweden, 24 - 27 June 2002), M. Johnson and C. Wheatley eds

Haupt, P. (2022). Thames Estuary Cockle Survey Report 2021. Kent and Essex Inshore Fisheries and Conservation Authority. 47 pp

Hawkins, A. D. and Popper, A. N. (2016) A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. ICES Journal of Marine Science, 74 (3): 635-651.

Hawkins, A., Roberts, L and Cheesman, S. (2014a). Responses of free-living coastal pelagic fish to impulsive sounds. Acoustical Society of America.pp. 3101-3116.

Hawkins, A. D., Pembroke, A. E., and Popper A., N. (2014b). Information gaps in understanding the effects of noise on fishes and invertebrates, Rev. Fish Biol. Fisheries. Springer International Publishing.

Hawkins, T. (2009). The impact of pile driving upon fish. Proceedings of the Institute of Acoustics Fifth International Conference on Bio-Acoustics, Loughborough, pp.69–76.

Hawkins, A. (2006). Effects on fish of pile driving, wind turbines, and other sources. The Journal of the Acoustic Society of America, 119(5), pp.3283.

Hazelwood, R. and Macey, P. (2016a). Modeling Water Motion near Seismic Waves Propagating across a Graded Seabed, as Generated by ManMade Impacts. Journal of Marine Science and Engineering. 4. 47. 10.3390/jmse4030047.

Hazelwood, R.A. and Macey, P.C. (2016b). Intrinsic directional information of ground roll waves. In The Effects of Noise on Aquatic Life II (pp.447-453). Springer, New York, NY.

Hazelwood, R.A. (2012). Ground roll waves as a potential influence on fish: measurement and analysis techniques. In The effects of noise on aquatic life (pp.449-452). Springer, New York, NY.

Heath, M.R. Neat F.C. Pinnegar J.K. Reid D.G. Sims D.W. and Wright P.J. (2012) Review of climate change impacts on marine fish and shellfish around the UK and Ireland. Aquatic Conservation: Marine and Freshwater Ecosystems 22: 337-367.

Hooper, T., & Austen, M. (2014). The co-location of offshore windfarms and decapod fisheries in the UK: Constraints and opportunities. Marine Policy, 43, 295.

Hutchison, Z.L., Gill, A.B., Sigray, P., He, H. and King, J.W. (2020). Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom dwelling marine species. Scientific Reports 10:4219.

Hvidt, C. B., Bech, M., & Klaustrup, M. (2004). Monitoring programme-status report 2003. Fish at the cable trace. Nysted offshore wind farm at Rødsand. Bioconsult.

Hyder, K., Weltersbach, M.S., Armstrong, M., Ferter, K., Townhill, B., Ahvonen, A., Arlinghaus, R., Baikov, A., Bellanger, M., Birzaks, J. and Borch, T., 2018. Recreational sea fishing in Europe in a global context—participation rates, fishing effort, expenditure, and implications for monitoring and assessment. *Fish and Fisheries*, *19*(2), pp.225-243.

ICES (1995) Underwater noise of research vessels: review and recommendations. ICES Cooperative Research Report, vol. 209. 61 pp

ICES (1965-2022) International Bottom Trawl Survey data. https://datras.ices.dk/Data_products/Download/Download_Data_public.aspx

ICES (2021). Celtic Seas ecoregion – Ecosystem Overview. ICES Ecosystem Overviews

Joint Nature Conservation Committee (JNCC) (2010). Guidelines for minimising the risk of injury to marine mammals from using explosives. JNCC, Peterborough.

Kalmijn, A. J. (1971). The Electric Sense of Sharks and Rays. Journal of Experimental Biology 55, 371–383.

Kastelein, R. (2008). Effects of vibrations on the behaviour of cockles (bivalve molluscs). Bioacoustics-the International Journal of Animal Sound and Its Recording - BIOACOUSTICS. 17. 74-75. 10.1080/09524622.2008.9753770.

Kastelein, R.A., Jennings, N., Kommeren, A., Helder-Hoek, L. and Schop, J. (2017). Acoustic dose-behavioral response relationship in sea bass (*Dicentrarchus labrax*) exposed to playbacks of pile driving sounds. Marine environmental research, 130, pp.315324.

Kimber, J. A., Sims, D. W., Bellamy, P. H. & Gill, A. B. (2011). The ability of a benthic elasmobranch to discriminate between biological and artificial electric fields. Marine Biology 158, 1–8.

Korringa, P., 1952. Recent advances in oyster biology. Quarterly Review of Biology, 27, 266-308 & 339-365.

Kosheleva, V. (1992) The impact of air guns used in marine seismic explorations on organisms living in the Barents Sea. Contr. Petro Piscis II `92 Conference F-5, Bergen, 6-8 April, 1992. 6 s.

Krone, R. Gutowa, L. Joschko, T.J. Schröder, A. (2013) Epifauna dynamics at an offshore foundation Implications of future wind power farming in the North Sea. Marine Environmental Research, 85, 1-12.

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

Lewandowski J., Luczkovich J., Cato D. and Dunlop R. (2016) Summary Report Panel 3: Gap Analysis from the Perspective of Animal Biology: Results of the Panel Discussion from the Third International Conference on the Effects of Noise on Aquatic Life. In Popper A.N. and Hawkins A.D. The effects of noise on aquatic life, II. (pp. 1277 - 1282). Springer Science+Business Media, New York

Lindegren, M. Diekmann, R. and Möllmann, C. (2010) Regime shifts, resilience and recovery of a cod stock. Marine Ecology Progress Series 402: 239-253

Linley, E. A. S., Wilding, T. A., Black, K. D., Hawkins, A. J. S. and Mangi, S. (2007) Review of the reef effects of offshore wind farm structures and potential for enhancement and mitigation. Report from PML Applications Ltd. to the Department of Trade and Industry.

Madsen, P. T. (2005) Marine Mammals and Noise: Problems with Root Mean Square Sound Pressure for Transients", J. Acoust. Soc. Am. 117, pp. 3952-3956.

Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K., & Tyack, A. P. (2006). Wind WTGs underwater noise and marine mammals: implications of current knowledge and data needs. *Marine ecology progress series*, *309*, 279-295.

Malme, C. I., Miles, P. R., Miller, G. W., Richardson, W. J., Reseneau, D. G., Thomson, D. H., Greene, C. R. (1989). Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska, BBN Report No. 6945 OCS Study MMS 89-0005. Reb. From BBN Labs Inc., Cambridge, MA, for U.S. Minerals Managements Service, Anchorage, AK. NTIS PB90-188673.

MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd, (2013). Environmental Effect Pathways between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments. A report for BMAPA.

McCauley, R. D. Fewtrell, J. Duncan, A. J. Jenner, C. Jenner, M-N. Penrose, J. D. Prince, R. I. T. Adhitya, A. Murdoch, J. and McCabe, K. (2000) Marine Seismic Surveys – A Study of Environmental Implications. Appea Journal, pp. 692-707.

Mitson, R.B. (1993). Underwater noise radiated by research vessels. ICES Marine Science Symposium 196: 147 – 152.

MMO (2020) UK Sea Fisheries Annual Statistics Report.

MMO (2022a) 2022 UK and foreign vessels landings by UK port and UK vessel landings abroad: provisional data

MMO (2022b). Thames and Blackwater spawning herring Licence: Schedule (23).

Mueller-Blenkle, C., McGregor, P.K., Gill, A.B., Andersson, M.H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D.T. & Thomsen, F. (2010) Effects of Pile-driving Noise on the Behaviour of Marine Fish. COWRIE Ref: Fish 06-08, Technical Report 31st March 2010

Nedwell, J. R. Parvin, S. J. Edwards, B. Workman, R. Brooker, A. G. and Kynoch, J. E. (2007) Measurement and Interpretation of Underwater Noise During Construction and Operation of Wind farms in UK waters, Subacoustech Report No. 544R0738 to COWRIE Ltd. ISBN: 978-0- 9554279-5-4

Neo, Y.Y., Seitz, J., Kastelein, R.A., Winter, H.V., ten Cate, C., Slabbekoorn, H., (2014). Temporal structure of sound affects behavioural recovery from noise impact inEuropean seabass. Biol. Conserv. 178, 65–73.

North Falls PEIR, Chapter 11, Fish and Shellfish Ecology. Available online at: https://www.northfallsoffshore.com/wp-content/uploads/2023/05/004447021-04_North-Falls-PEIR_Chapter-11-Fish-and-Shellfish-Ecology.pdf

Ohman, M. C., Sigray, P. & Westerberg, H. (2007). Offshore windmills and the effects of electromagnetic fields on fish. Ambio 36, 630–633.

Oldfield, R. G. (2011). Aggression and welfare in a common aquarium fish, the Midas cichlid. Journal of Applied Animal Welfare Science, 14, 340–360. [PubMed] [Google Scholar]

Orpwood, J. E., Fryer, R. J., Rycroft P. & J D Armstrong (2015). Effects of AC Magnetic Fields (MFs) on Swimming Activity in European Eels *Anguilla*, Scottish Marine and Freshwater Science Vol 6 No 8

Palma, J., Magalhães, M., Correia, M. and Andrade, J.P. (2019). Effects of anthropogenic noise as a source of acoustic stress in wild populations of *Hippocampus guttulatus* in the Ria Formosa, south Portugal. Aquatic Conservation: Marine and Freshwater Ecosystems, 29(5), pp.751–759.

Pawson, M. G. (1995). http://www.cefas.co.uk/Publications/techrep/tech99.pdf (No. 99) (p. 72). Lowestoft: MAFF Directorate of Fisheries Research. Retrieved from http://www.cefas.co.uk/Publications/techrep/tech99.pdf

Payne, J.F. Andrews, C.A. Fancey, L.L. Cook, A.L. and Christian, J.R. (2007) Pilot Study on the Effect of Seismic Air Gun Noise on Lobster (*Homarus Americanus*) Canadian Technical Report of Fisheries and Aquatic Sciences No.2712:V + 46 (2007).

Pearson, W. H. Skalski, J.R and Malme, C.I. (1992). Effects of sounds from a geophysical survey device on behaviour of captive rockfish (*Sebastes* spp.). Can. J. Fish. Sci. 49: 1343-1356

Peña, H., Handegard, N.O. and Ona, E. (2013). Feeding herring schools do not react to seismic air gun surveys. ICES Journal of Marine Science, 70(6), pp.1174–1180.

Perry, F., & Jackson, A. (2017). *Ostrea edulis* Native oyster. In H. Tyler-Walters & K. Hiscock (Eds.), Marine life information network: Biology and sensitivity. Key information reviews. Plymouth: Marine Biological Association of the United Kingdom

Picciulin, M. et al. (2022) 'A Fish and Dolphin Biophony in the Boat Noise-Dominated Soundscape of the Cres-Lošinj Archipelago (Croatia)', Journal of Marine Science and Engineering, 10(2), p. 300. doi:10.3390/jmse10020300.

Pierri, Cataldo, Tamara Lazic, Michele Gristina, Giuseppe Corriero, and Mauro Sinopoli. (2022) Large-Scale Distribution of the European Seahorses (*Hippocampus Rafinesque*, 1810): A Systematic Review. Biology 11, 2: 325. https://doi.org/10.3390/biology11020325.

PINS, 2021. Scoping Opinion Proposed Five Estuaries Offshore Windfarm

Popper, A.N. and Hastings, M.C. (2009). The Effects of Anthropogenic Sources of Sound on Fishes. Journal of Fish Biology, 75, pp.455–489.

Popper, A.N. Salmon, M. and Horch, K.W. (2001). Acoustic detection and communication by decapod crustaceans. Journal of Comparative Physiology A, 187(2), pp.83–89.

Popper A.N., and Hawkins A.D. (2018). The importance of particle motion to fishes and invertebrates. The Journal of the Acoustical Society of America 143, 470 (2018); doi: 10.1121/1.5021594

Popper, A. N. Hawkins, A. D. Fay, R. R. Mann, D. Bartol, S. Carlson, Th. Coombs, S. Ellison, W. T. Gentry, R. Hal vorsen, M. B. Lokkeborg, S. Rogers, P. Southall, B. L. Zeddies, D. G. and Tavolga, W. N. (2014) Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

PowerGen Renewables Offshore Ltd. (2001). Scroby Sands Offshore Windfarm Environmental Impact Assessment.

Prakash, Sadguru, and Seema Srivastava. (2019) Impact of Climate Change on Biodiversity: An Overview. International Journal of Biological Innovations, 01: 60–65.

Radford, A.N., Lèbre, L., Lecaillon, G., Nedelec, S.L. and Simpson, S.D. (2016). Repeated exposure reduces the response to impulsive noise in European seabass. Global Change Biology, 22(10), pp.3349–3360

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 spawning herring Potential Spawning Areas. A Method Statement produced for the British Marine Aggregates Producers Association.

REW, 2023. 004447021-04_North-Falls-PEIR_Chapter-11-Fish-and-Shellfish-Ecology.pdf. Available at: northfallsoffshore.com.

Richardson WJ, Greene CR Jr, Malme CI, Thomson DH (1995) Marine mammals and noise. Academic Press, New York, 577 p

Regnier, Thomas, Fiona Gibb, and Peter Wright. (2019) Understanding Temperature Effects on Recruitment in the Context of Trophic Mismatch. Scientific Reports, 9.

Roach, M and Cohen, M. (2015) Westermost Rough Fish & Shellfish Monitoring Report 2015; Including Comparison to Baseline Data 2013

Roberts L. (2015) Behavioural responses by marine fishes and macroinvertebrates to underwater noise (Doctoral dissertation, University of Hull). Roberts, L. Cheesman, S. Elliott, M. and Breithaupt, T. (2016) Sensitivity of *Pagurus bernhardus* (L.) to substrate-borne vibration and anthropogenic noise. Journal of Experimental Marine Biology and Ecology, 474: 185–194.

Roberts L, Cheesman S, Hawkins AD. (2016) Effects of Sound on the Behaviour of Wild, Unrestrained Fish Schools. Adv Exp Med Biol. 2016;875:917-24. doi: 10.1007/978-1-4939-2981-8_113. PMID: 26611050.

Robinson, S, Lepper, P and Ablitt, J. (2007). The measurement of the underwater radiated noise from marine piling including characterisation of a soft start period. OCEANS 2007 - Europe. 1 - 6. 10.1109/OCEANSE.2007.4302326.

Royal Haskoning DHV (2019). East Anglia ONE North Environmental Impact Assessment.

RWE (2023). North Falls Offshore Windfarm Preliminary Environmental Information Report Chapter 11 Fish and Shellfish Ecology.

Samson JE, Mooney TA, Gussekloo SWS and Hanlon RT (2016) A Brief Review of Cephalopod Behavioral Responses to Sound. In Popper A.N., and Hawkins A.D. The effects of noise on aquatic life, II. (pp. 969 - 976). Springer Science+Business Media, New York.

Sand, O. Enger P. S. Karlsen H. E. and Knudesen, F. R. (2001) Detection of Infrasound in Fish and Behavioural Responses to Intense Infrasound in Juvenile Salmonids and European Silver Eels: A Mini Review, Am. Fish Soc. Symp. 26, pp. 183 - 193.

Sigray, P. and Andersson, M.H. (2011) Particle Motion Measured at an Operational Wind WTGs in Relation to Hearing Sensitivity in Fish. J. Acoustic Soc. Am. 130(1) pp.200-207.

Skaret, G. Axelsen, B. E. Nøttestad, L. Ferno, A. and Johannessen, A. (2005) The behaviour of spawning herring in relation to a survey vessel. ICES Journal of Marine Science, 62: 1061– 1064.

Spiga, I., Aldread, N. and Caldwell, G.S. (2017). Anthropogenic noise compromises the anti-predator behaviour of the European seabass, *Dicentrarchus labrax* (L.). Marine Pollution Bulletin, 122, pp.297–305.

Spiga I., Caldwell G.S. and Bruintjes R. (2016) Influence of Pile Driving on the Clearance Rate of the Blue Mussel, *Mytilus edulis* (L.). In: Fourth International Conference on the Effects of Noise on Aquatic Life. 2016, Dublin, Ireland: Acoustical Society of America.

Todd, V., Todd, I., Gardiner, J. and Morrin, E. (2015). Marine mammal observer and passive acoustic monitoring handbook. Pelagic Publishing Ltd.

Tougaard, J. and Henriksen, O. D. (2009) Underwater Noise Form Three Types of Offshore Wind WTGss: Estimation of Impact Zones for Harbour Porpoises and Harbour Seals. J. Acoust. Soc. Am. 125, pp. 3766-3773.

Tricas, T., and Gill, A. (2011). Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Page 255 of 256 Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Tyler-Walters, H. (2007a). *Cerastoderma edule* Common cockle. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 07-01-2023]. Available from: https://www.marlin.ac.uk/species/detail/1384

Tyler-Walters, H. (2007b). *Nucella lapillus* Dog whelk. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 07-01-2023]. Available from: https://www.marlin.ac.uk/species/detail/1501

Vattenfall, A.B., 2019. Vattenfall Europe AG, Vattenfall Europe Generation AG v. Federal Republic of Germany, ICSID Case No. ARB/09/6 (11 March 2011).

Wahlberg, M. and Westerberg, H. (2005) Hearing in Fish and their Reactions to Sounds from Offshore Wind Farms. Mar.Ecol. Prog. Ser. 288, pp. 295 – 309.

Walker M, Diebel CE, Haugh CV, Pankhurst PM, Montgomery JC, Green CR (1997) Structure and function of the vertebrate magnetic sense. Nature 390:371–376

Walmsley, S., (2006). Thames bass trawl survey. Cefas, Lowestoft, UK. 25pp.

Westerberg, H. (2000). Effect of HVDC cables on eel orientation. Pages 70-76 in Technische Eingriffe in marine Lebensraume. Bundesamtes für Naturschutz, Germany.

Westerhagen, H. V (1988) Sublethal Effects of Pollutants on Fish Eggs and Larvae. In: Fish Physiology. Volume 11, Part A, pp 253-234. Academic Press, New York.

Wilhelmsson, D. and Malm, T. (2008) Fouling assemblages on offshore wind power plants and adjacent substrata. Estuarine, Coastal and Shelf Science 79(3) pp 459-466.

Yano, K., H. Mori, K. Minamikawa, S. Ueno, S. Uchida, K. Nagai, M. Toda, and M. Masuda. (2000). Behavioral Response of Sharks to Electric Stimulation. Bulletin of Seikai National Fisheries Research Institute 78:13- 30.

Yonge, C.M., 1960. Oysters. London: Collins.

Zhang, Y, Shi F, Song J, Zhang X and Yu S (2015) Hearing characteristics of cephalopods: Modelling and environmental impact study. Integrative Zoology 10 (1) 141–151 http://onlinelibrary.wiley.com/doi/10.1111/1749-4877.12104/full